

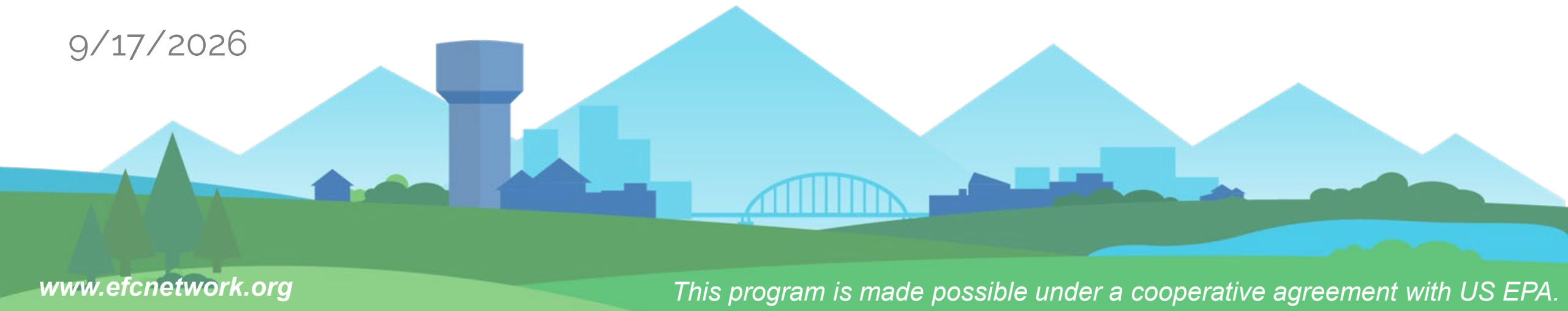


SOUTHWEST
ENVIRONMENTAL
FINANCE CENTER

US Territories Water Operator Training Series

Session 20: Distribution 3: Water Storage Tanks and Pumps

9/17/2026



Your trainers for today



Matt Ziegler
Program Director



Shā Lager
Water Utility Trainer &
Support Specialist



SOUTHWEST
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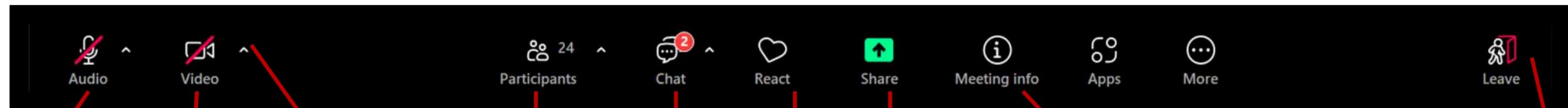
SCHOOL OF
ENGINEERING



This training series is funded by the US EPA

Attendee Meeting Controls

- Locate your control bar
- All attendees will see a black horizontal bar on their screen
- If your control bar is not visible, it may be hidden
 - Move your cursor to the screen's bottom (or top) to reveal this control bar.



1. Mute/unmute

2. Start/stop
your video

3. Enable Virtual
Background

4. View Meeting
Participants

5. Chat

6. Reactions/raise hand

7. Share
screen

8. Meeting
info

9. Leave meeting

Schedule for 2026:

Date	Topic
1/22/26	Alternative Treatment Processes (e.g. flouridation, ion exchange, RO...)
2/5/26	Drinking Water Treatment Math & Concept Review
2/19/26	Safety Program Basics (including personal safety, equipment safety, facility safety)
3/5/26	Lead & Copper Rule, Corrosion Control
3/19/26	Distribution Systems 1: Hydraulics, Pipe Types, Selection, Installation, and Water Quality
4/2/26	Distribution Systems 2: Valves, Hydrants, Meters, and Service Connections
9/17/26	Distribution Systems 3: Storage and Booster Pumping
10/1/26	O&M: Pumps, Main, and Appurtenance Maintenance (including pressure monitoring, valve exercising, and flushing)
10/15/26	O&M: Cross Connection Control
10/29/26	O&M: Distribution System Math and Concept Review
11/12/26	Sampling & Lab Procedures/Analysis/Interpretation
12/3/26	Management Overview (including organization, communication, PR & record keeping)
12/17/26	Drinking Water Practice Exam and Review

Links to recordings and material are available on our website at <https://swefc.unm.edu/home/op-cert-trainings/>

Pacific Island Territories Operator Certification Trainings

This page is a repository of Wastewater and Drinking Water Operator Certification (Op Cert) Training Webinars offered by the SW EFC for systems in the Pacific Territories. Below you will find the **training webinar schedules (wastewater, then drinking water)** followed by a **training webinar recordings library**.

[Jump to Wastewater Trainings](#) ↓

[Jump to Drinking Water Trainings](#) ↓

Wastewater Training Schedule

Please note all times are local to CNMI and Guam. The times in American Samoa are one day earlier at 11 am.

Session	Date	Training Topic & Link to Recording (click to view)	Supporting Materials (click to download)
1	6/25/2025	Program Overview, Test Format, Study & Test Tips	PPT slides
2	7/9/2025	Treatment Overview	PPT slides
3	7/23/2025	WW Math Part 1 (Areas & Volumes)	PPT slides
4	8/6/2025	WW Math Part 2 (Flow Rates & Detention Times)	PPT slides
5	8/20/2025	Collection Systems – Gravity systems	PPT Slides

Sign in for every session to ensure you get credit for attending



US Territories Water & Wastewater Operator Certification
Virtual Training Series Group Attendance Sheet

Session Title: _____
Session Date: _____
Training Location: _____

Attendee Name	Attendee Signature	Arrival Time	Departure Time

I hereby certify that the individuals listed above attended the referenced training session.

Name: _____
Signature: _____
Title: _____
Date: _____

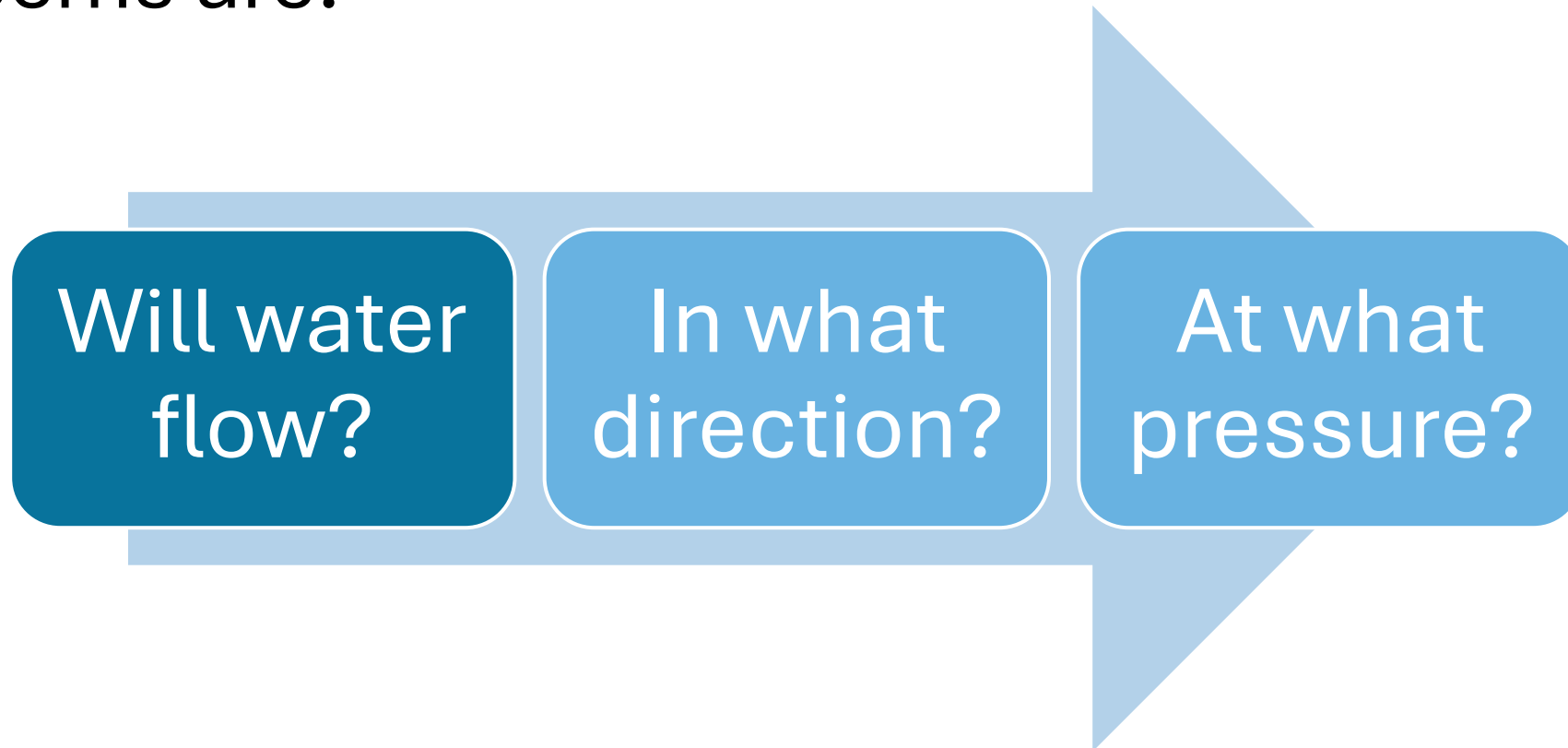
Today's Agenda

- Hydraulic Basics
- Water Storage Tanks
- Pumps
 - Basics
 - Types
 - O&M



Hydraulics Basics

For distribution systems, the major hydraulic concerns are:



Hydraulics Terminology

- Force
 - push of water against confining surfaces (lbs)
- Pressure
 - force per unit area (lbs/sq. in.) (psi)
 - increases with depth (height)
 - acts the same in all directions
- Head
 - distance from a free water surface to a reference point below the surface (feet)
 - the height of the water column to be pumped (feet)



gravity flow **1 foot of water**..... = 0.433 psi
1 pound per square inch..... = 2.31 ft of water

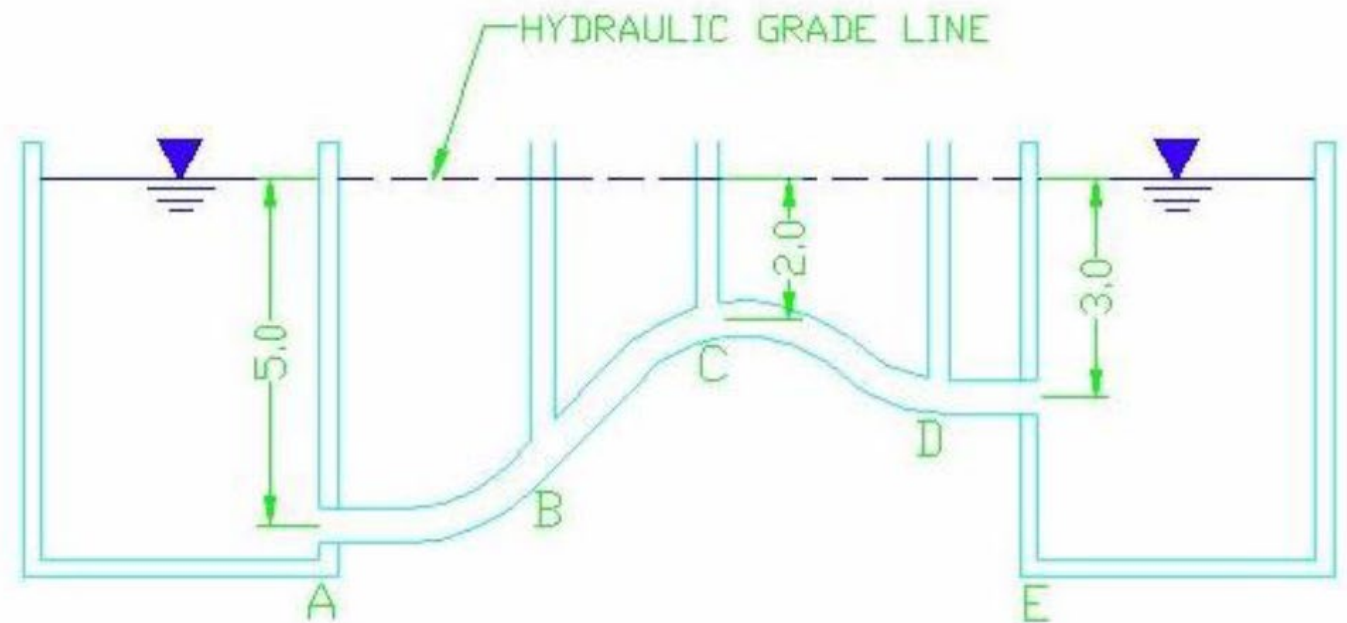
Hydraulics Terminology

- Velocity
 - The speed at which a particle of a substance is moving
 - Distance traveled over time (feet per second, ft/sec, fps)
- Flow Rate
 - The speed at which a unit of volume is moving
 - Distance that a unit of volume moves over time
 - Gallons per minute, gal/min, gpm
 - Cubic feet per second, ft³/sec, cfs
 - Million gallons per day, MGD



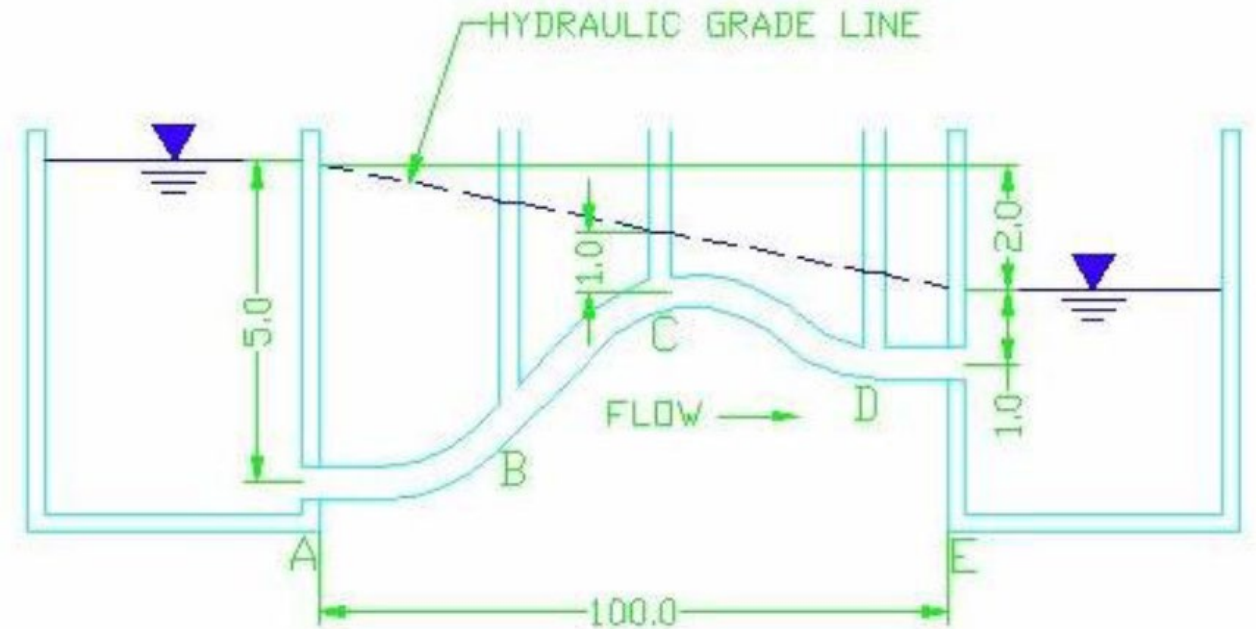
The Hydraulic Gradient Line

- Water seeks its own level
- The HGL is the height to which a column of water will rise if a vertical riser is placed on a pipe under pressure



Static Head and the HGL

- Static head is pressure due to elevation differences
- 2.0' is the static head in this case
- Water only flows by gravity from a higher HGL to a lower HGL



Dynamic Head

- Dynamic head are losses in head due to movement of water (flow) through the pipe
- Dependent on fluid type, density, viscosity, flow rate
- Dependent on pipe type, size, and changes in direction as water moves through the system.



Dynamic Head

- Minor losses due to changes in pipe size, shape, or direction
 - K-factor – flow loss coefficient

MINOR LOSS "K" FACTORS
FOR VARIOUS VALVES AND FITTINGS

90-Degree Bend - 4 to 16 Inch	0.3
90-Degree Bend - 18 to 24 Inch	0.4
90-Degree Bend - 30 to 54 Inch	0.6
Tee - Run of Tee	0.1
Tee - Through Side Outlet	1.2
Gate Valve	0.2
Butterfly Valve - 4 to 8 Inch	0.7
Butterfly Valve - 10 to 20 Inch	0.5
Butterfly Valve - 24 to 54 Inch	0.3
Eccentric Plug Valve	1.0
Swing Check Valve	1.8
Ball/Cone Valve	0.1

Typical C factors used in design, which take into account some increase in roughness as pipe ages

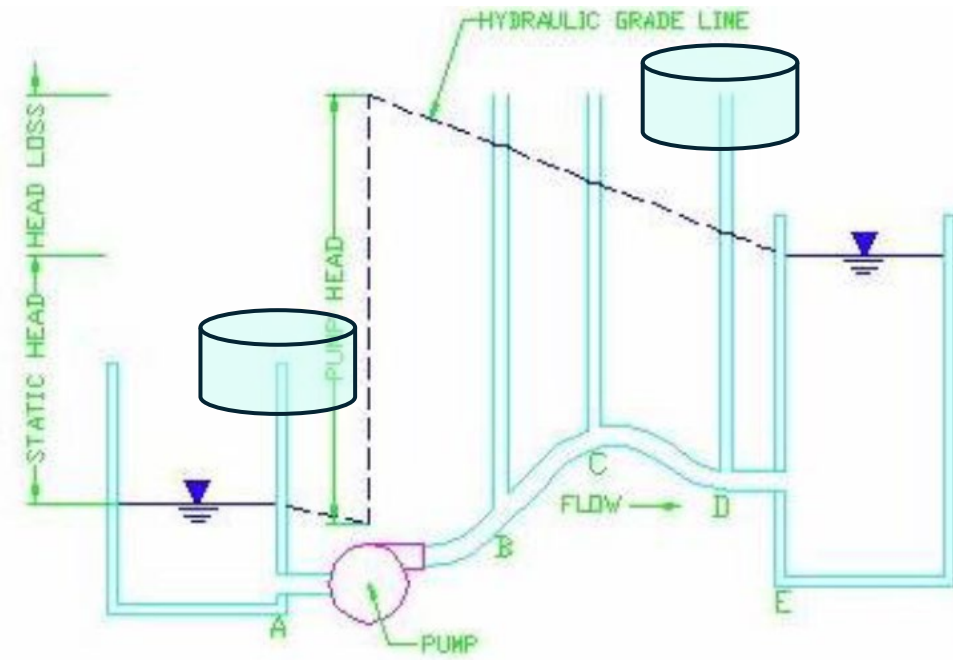
Material	C Factor low	C Factor high
Asbestos-cement	140	140
Cast iron new	130	130
Cast iron 10 years	107	113
Cast iron 20 years	89	100
Cement-Mortar Lined Ductile Iron Pipe	140	140
Concrete	100	140
Copper	130	140
Steel	90	120
Galvanized iron	120	120
Polyethylene	140	140
Polyvinyl chloride (PVC)	150	150
Fibre-reinforced plastic (FRP)	150	150

- Losses due to pipe material smoothness (rough = more loss, smooth = less loss)
 - Hazen-Williams C-factor (the higher the value the smoother the pipe surface)

Total Dynamic Head and the HGL

$$\text{Total Dynamic Head} = \text{Static Head} + \text{Dynamic Head}$$

- TDH is the total equivalent height that a fluid needs to be pumped including dynamic head losses (friction losses)
- Pumping applies an energy or force to lift water from a lower elevation (or level) to a higher elevation (or level) = Pump Dynamic Head (PDH).



Water Storage Tanks



Water Storage Tanks

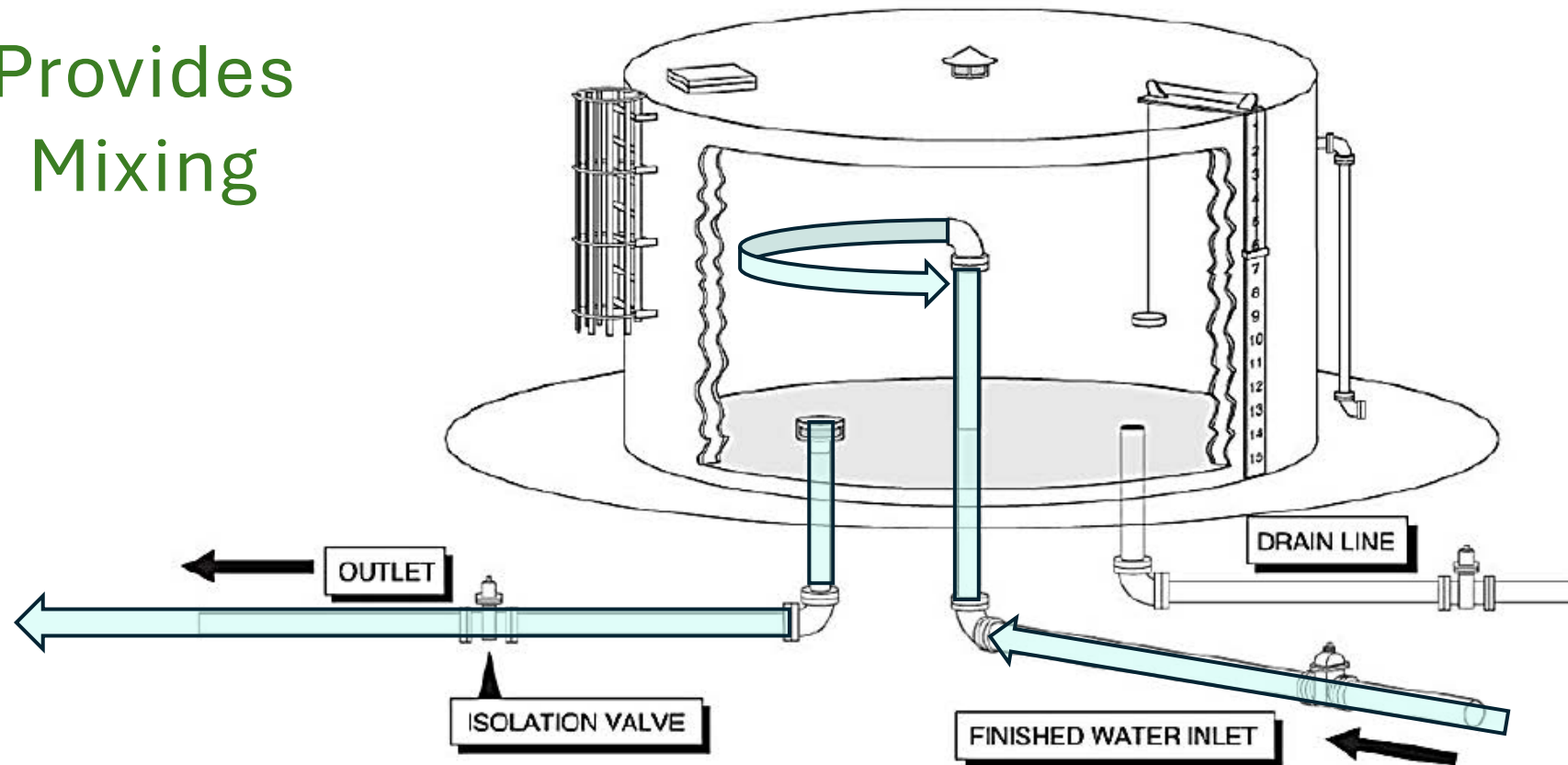
- Provides finished water storage in the distribution
- Ensures adequate water reserves to meet average and peak demand as well as for emergencies
- Helps maintain good distribution water pressures
- Can aid in the treatment process
 - Ensures adequate disinfection ($C \times T$)
 - Allows for off gassing of CO_2
 - Allows for the precipitation of contaminants
 - Blending of sources of different quality

***A barrier to preventing
waterborne disease***



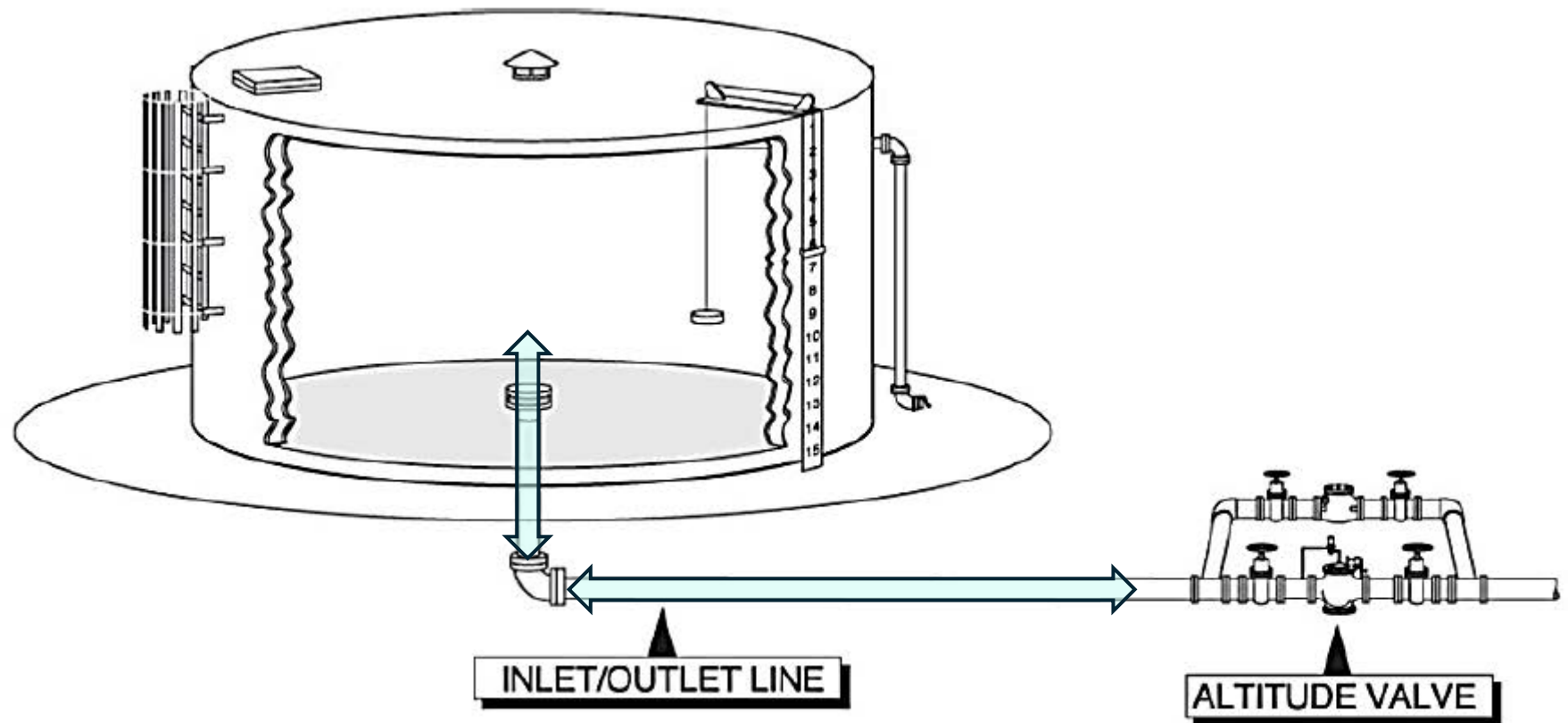
Direct Pumping Tank (Flow Through)

Provides
Mixing



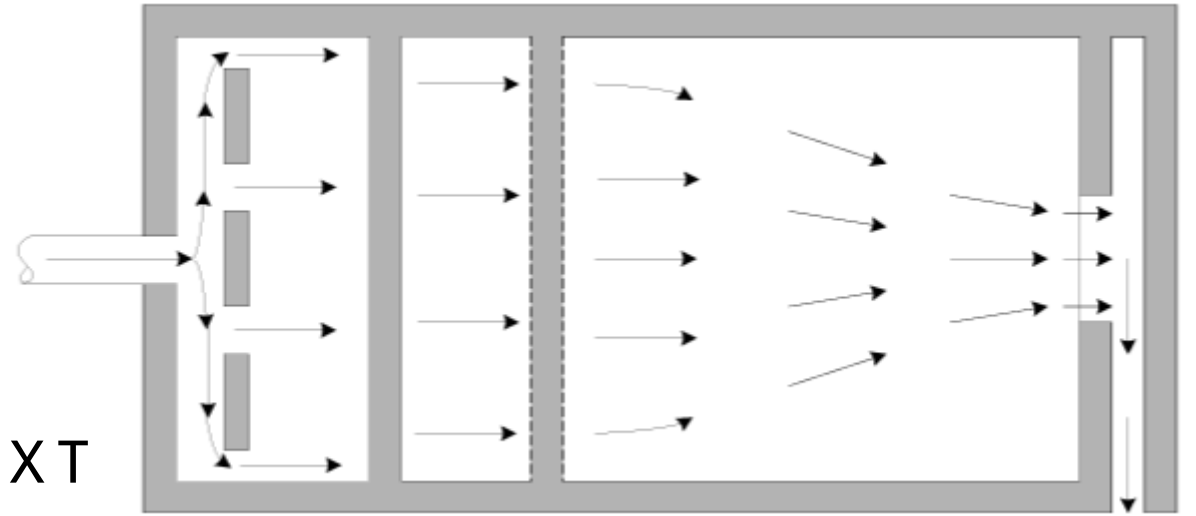
Side Stream Tank (Floating)

Water
Demand is
Met Before
Filling

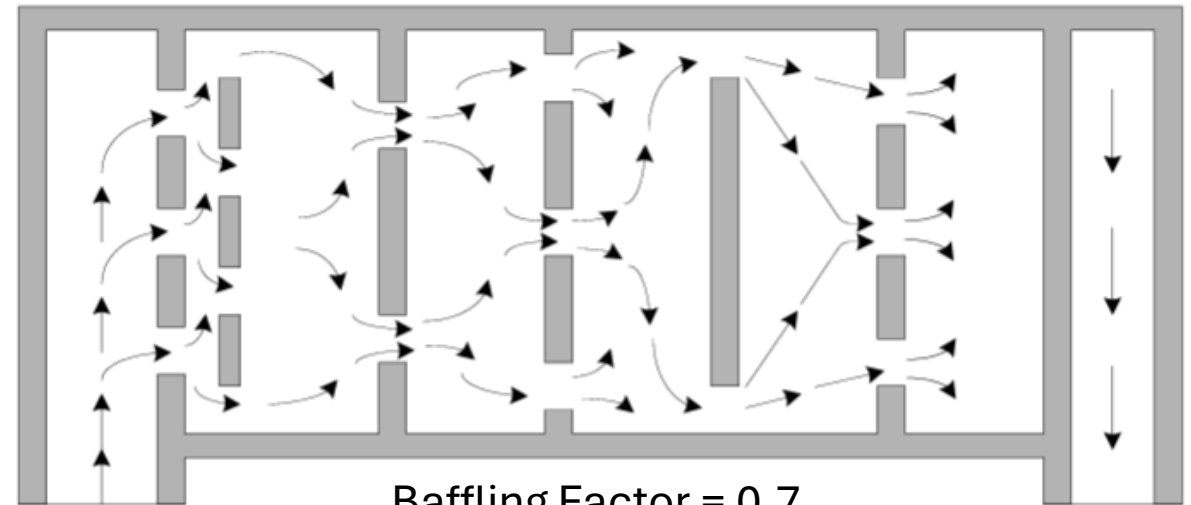
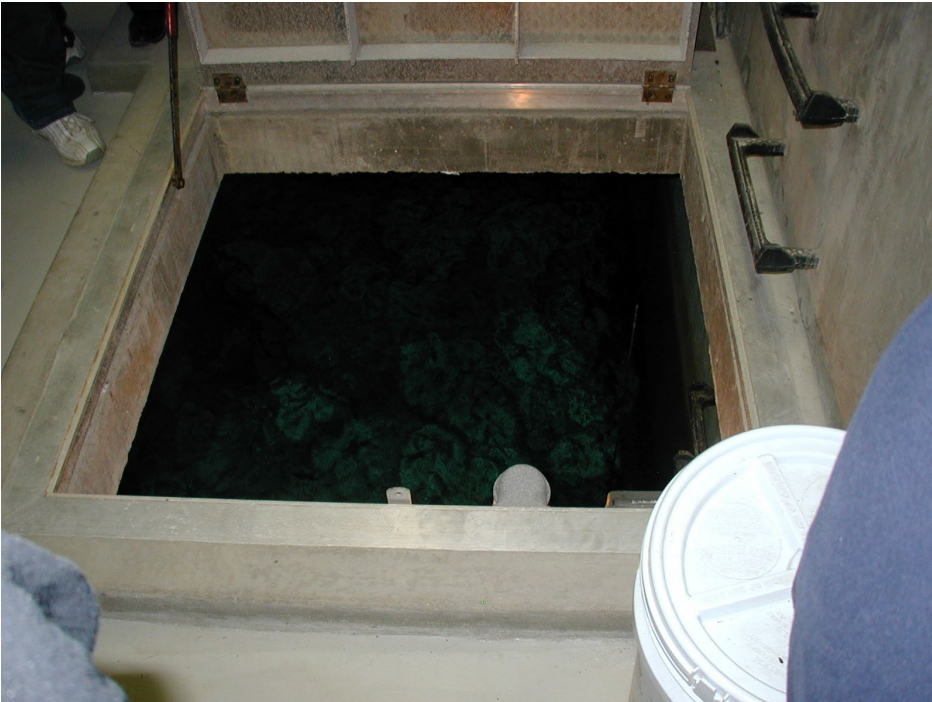


Type – Clear Wells

- Store filtered water at treatment plant
- Allows treatment plant to run at continuous rate during peak demand
- Provides additional treatment to meet $C \times T$



Baffling Factor = 0.5



Baffling Factor = 0.7

Type – Underground Tank



Type – Ground Level



Type - Standpipe

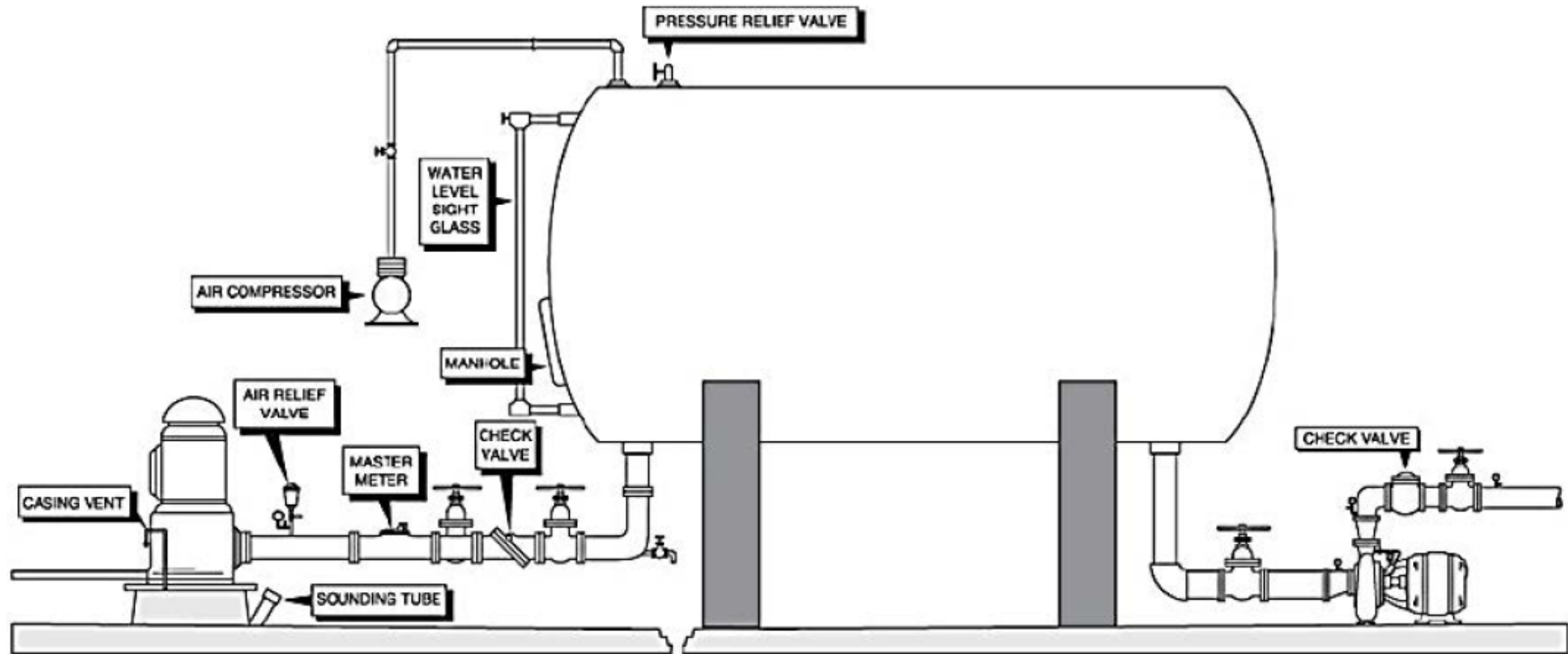
Height > Diameter



Type – Elevated

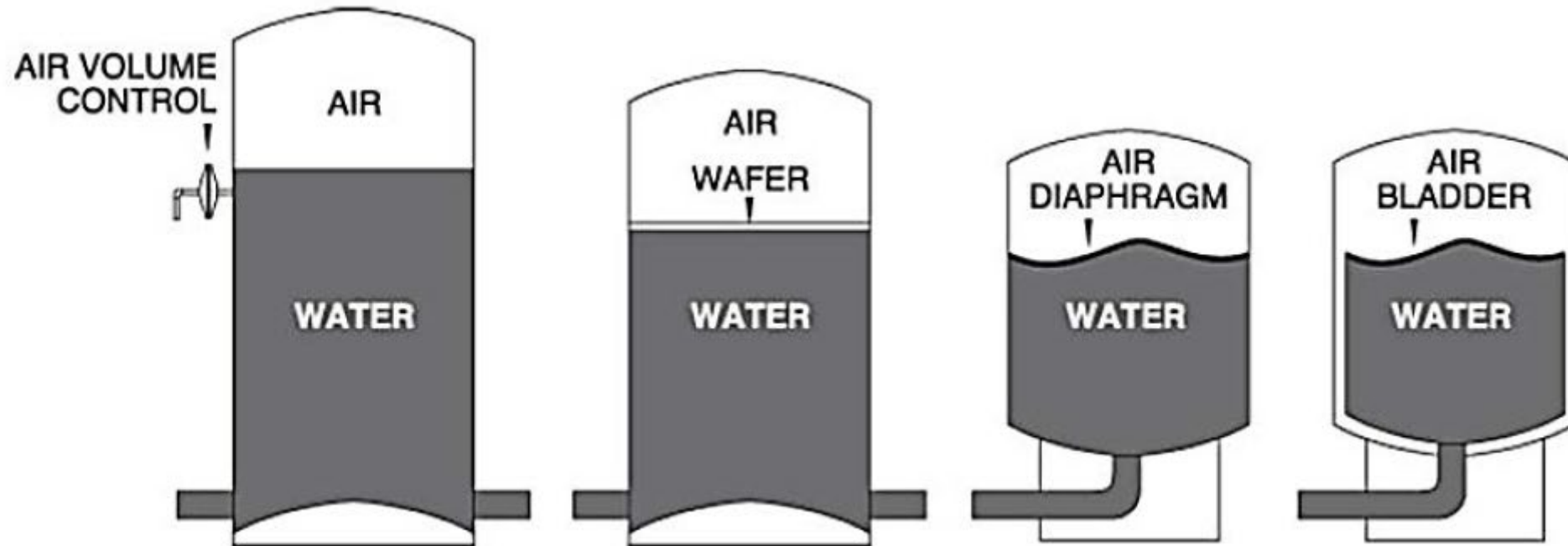


Type – Pressure Tank



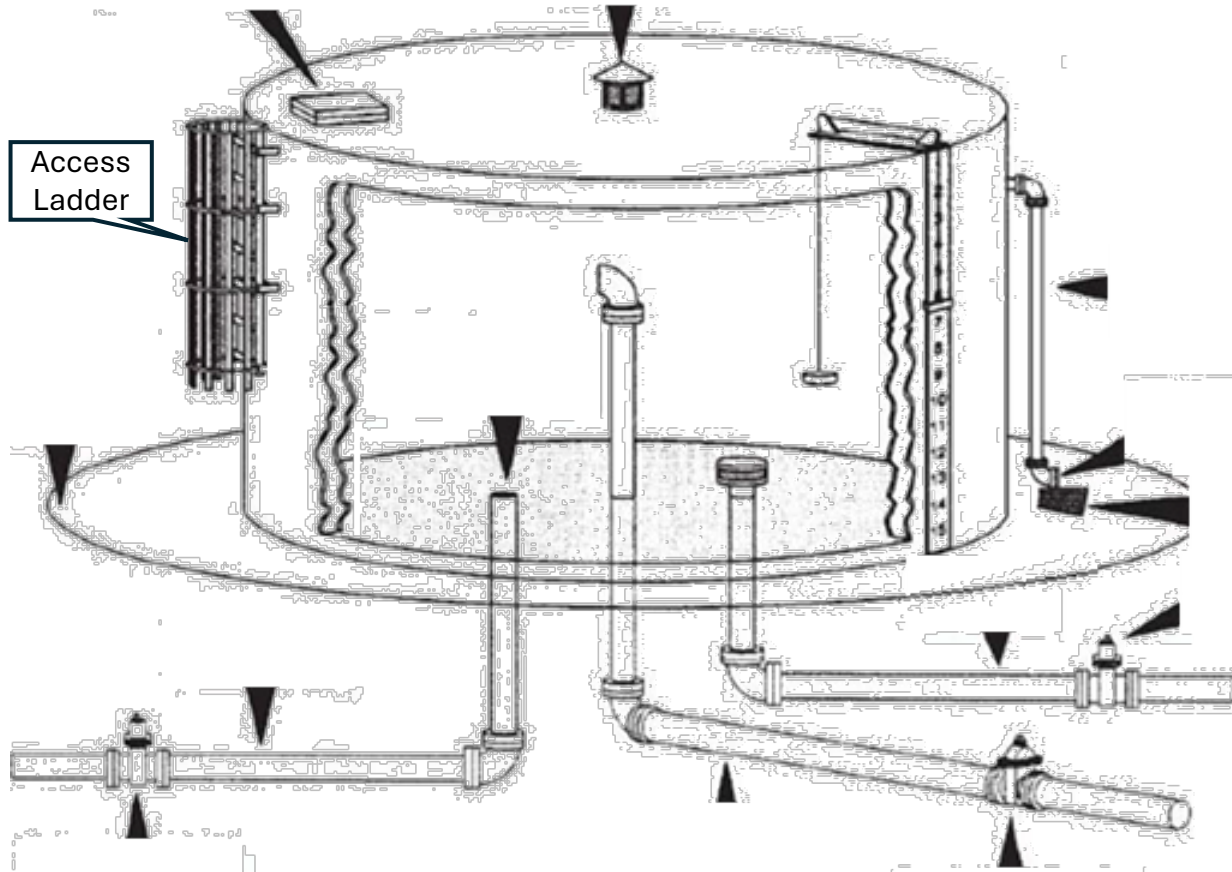
Type – Surge Tank

For Pump Control
& Water Hammer
Supression



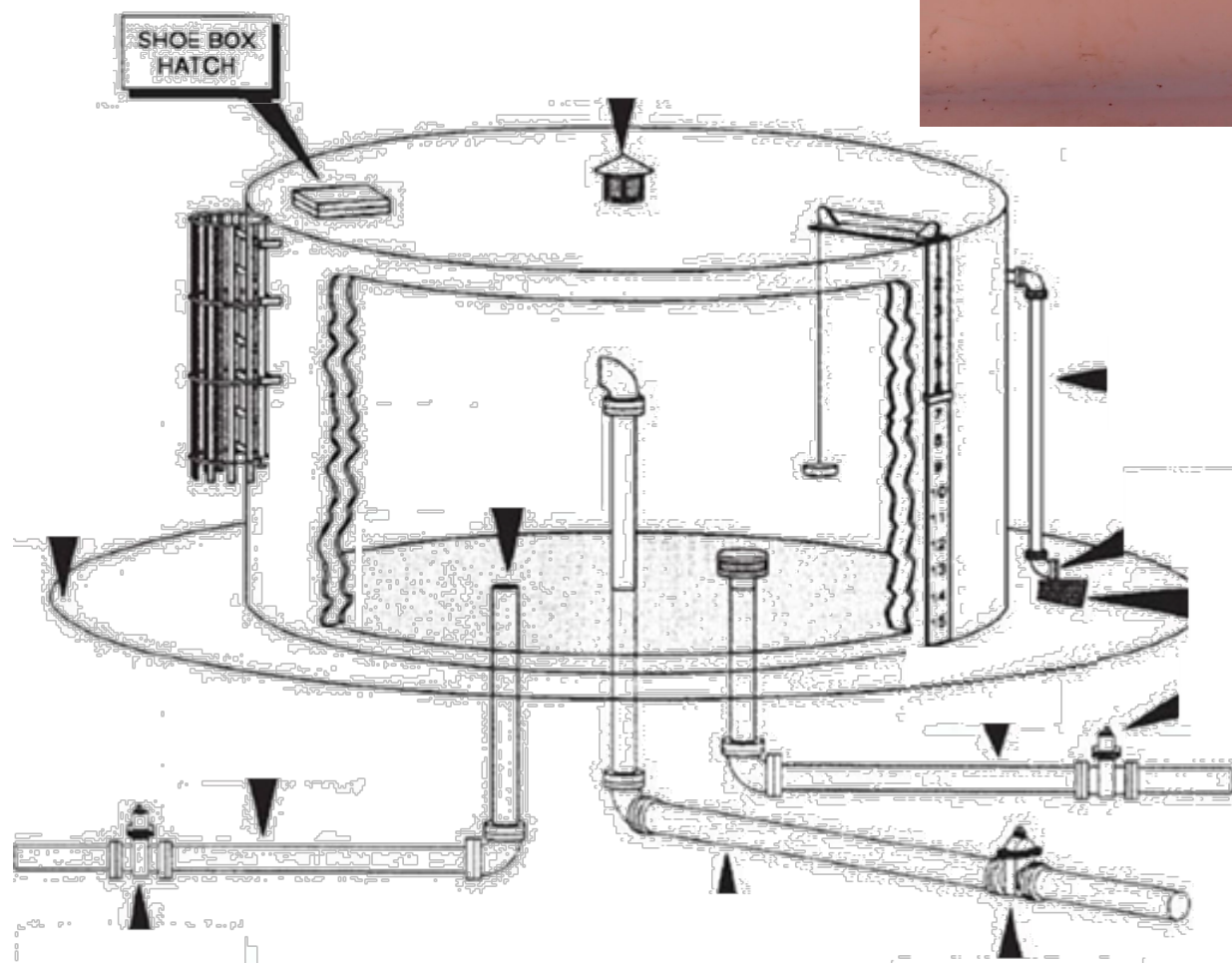
Tank Components Access Ladder

Limits Access
and Protects
Personnel



Tank Components

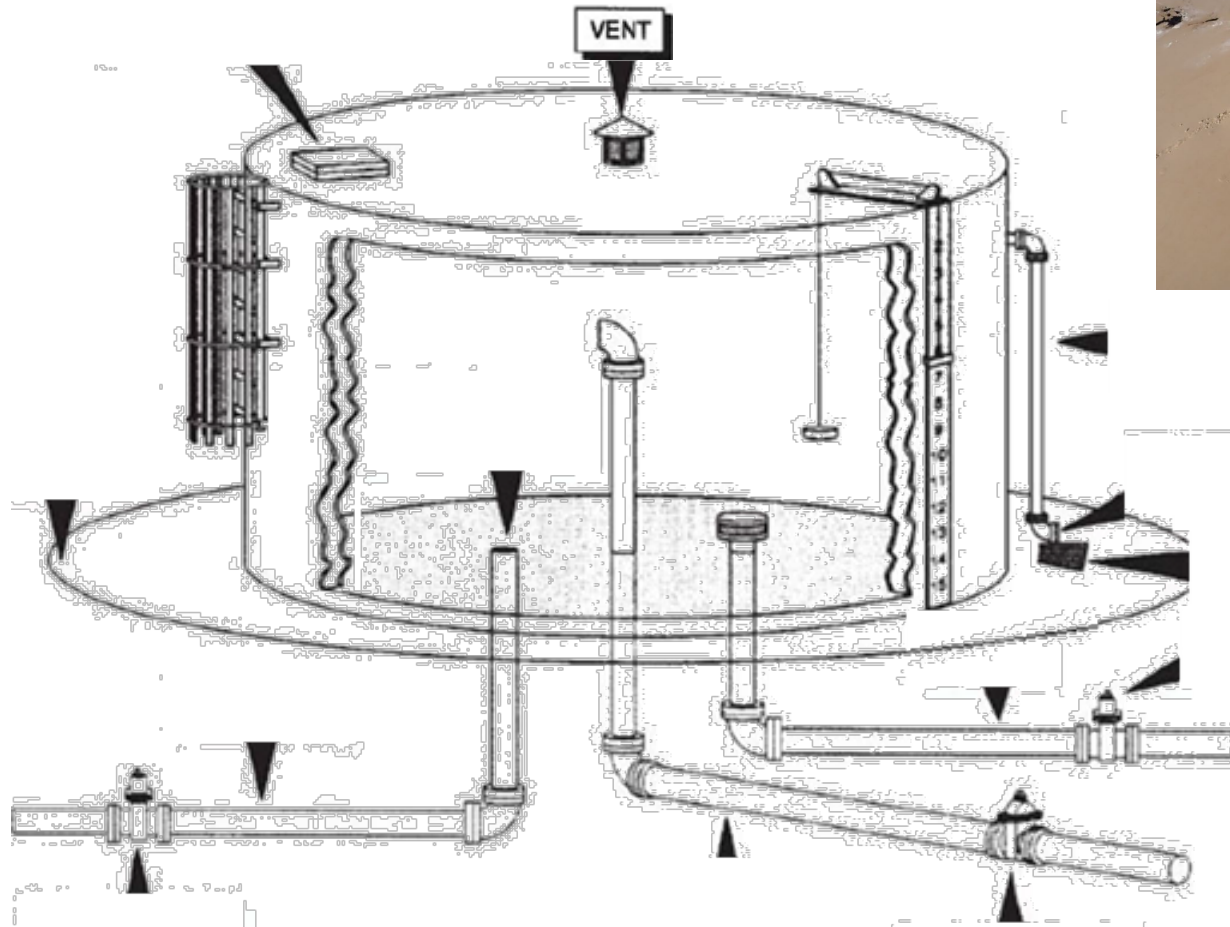
Access Hatch



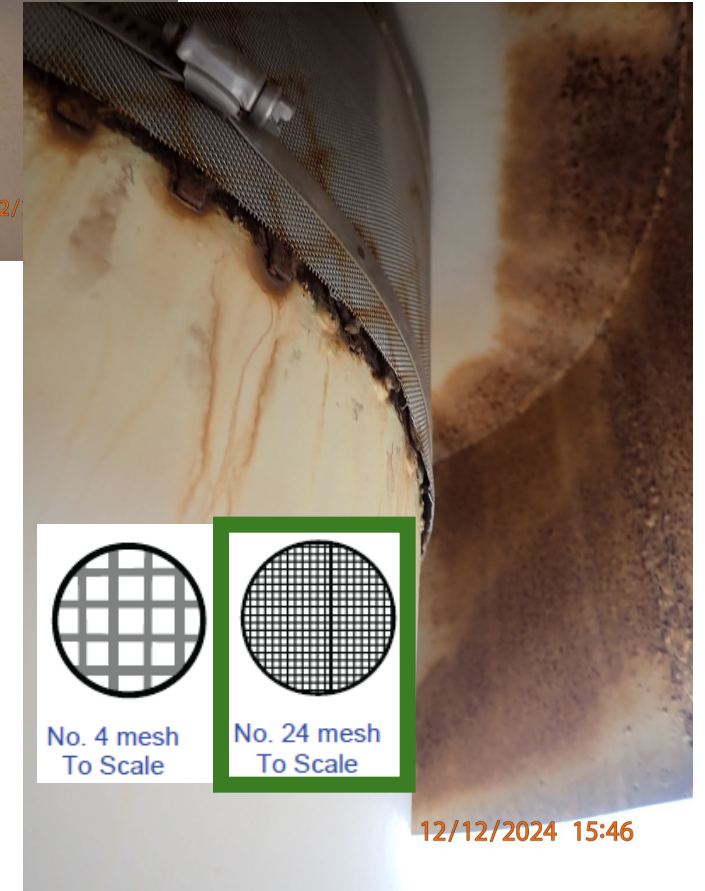
Limits
Access &
Protects
Water
Quality

Tank Components

Vent



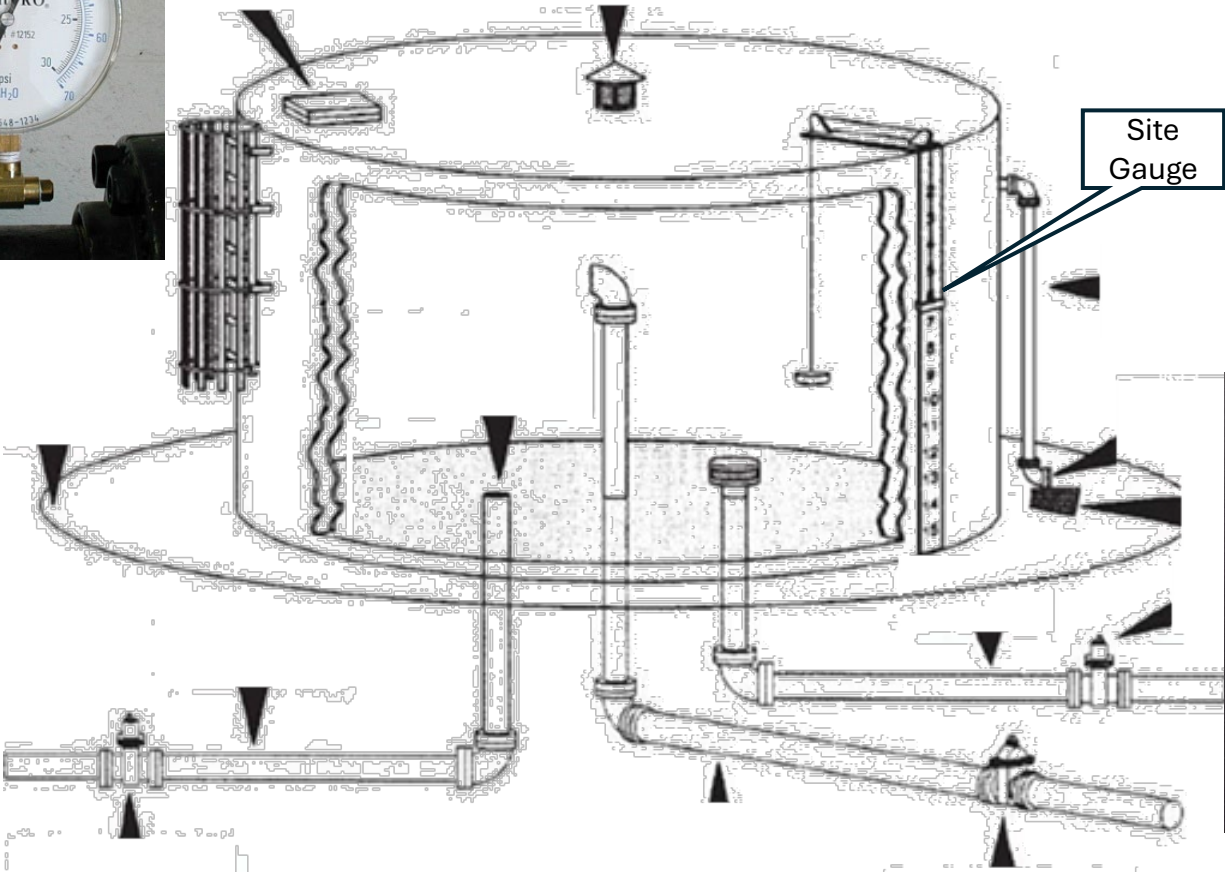
Allows Tank to
Breathe &
Protects
Water Quality



Tank Components

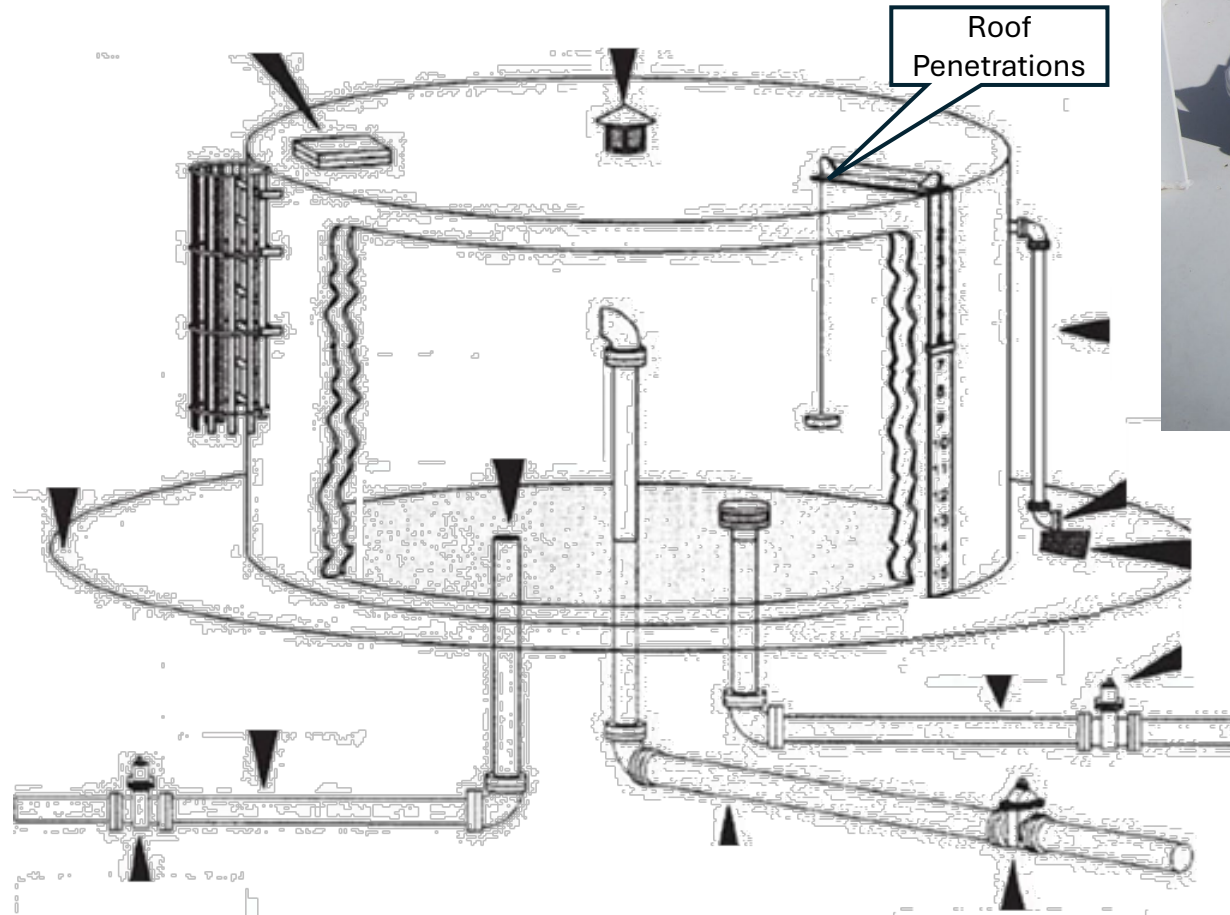
Site Gauge

Provides Visual Indication of Water Quantity



Tank Components

Roof Penetrations

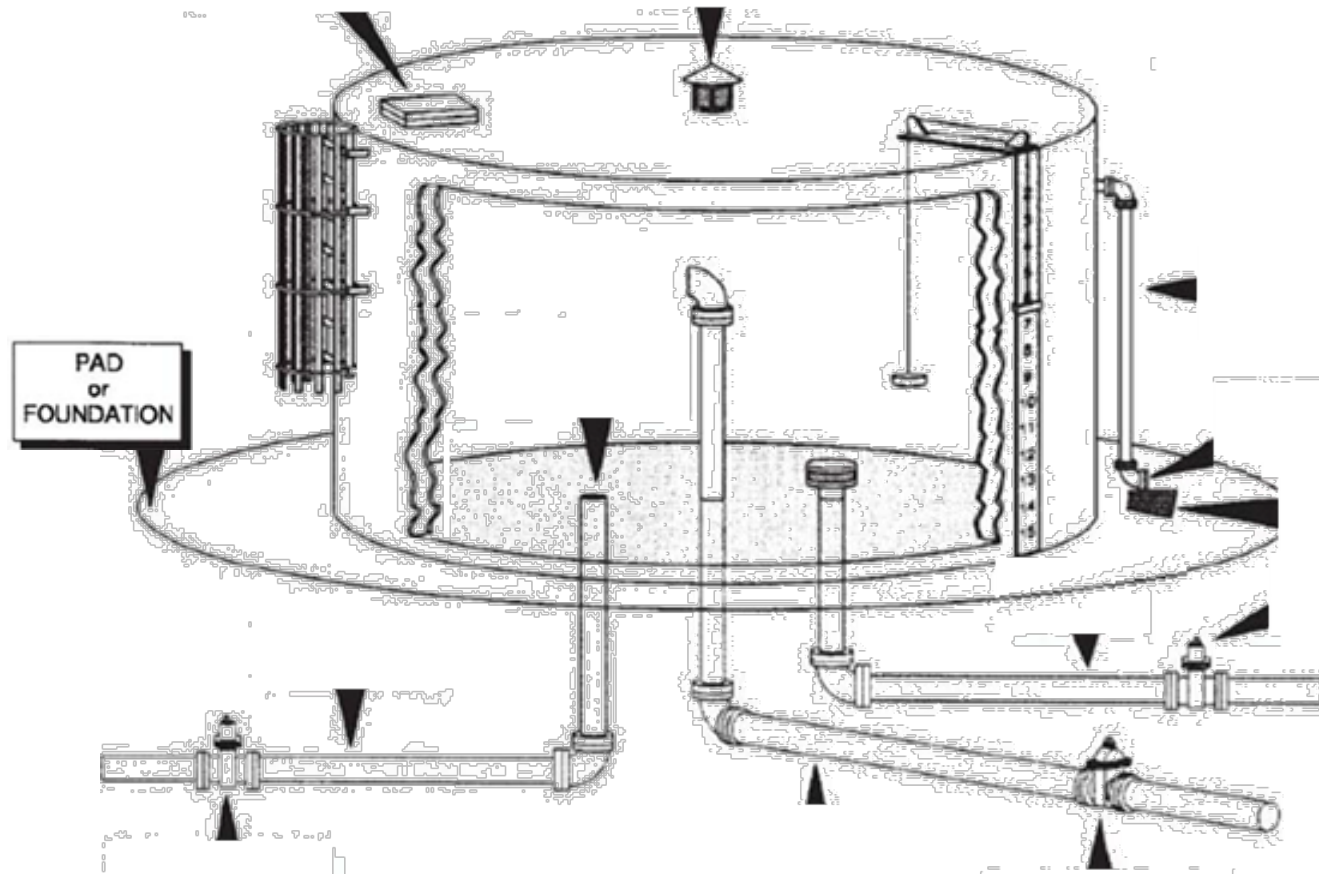


Sealed to
Protect Water
Quality

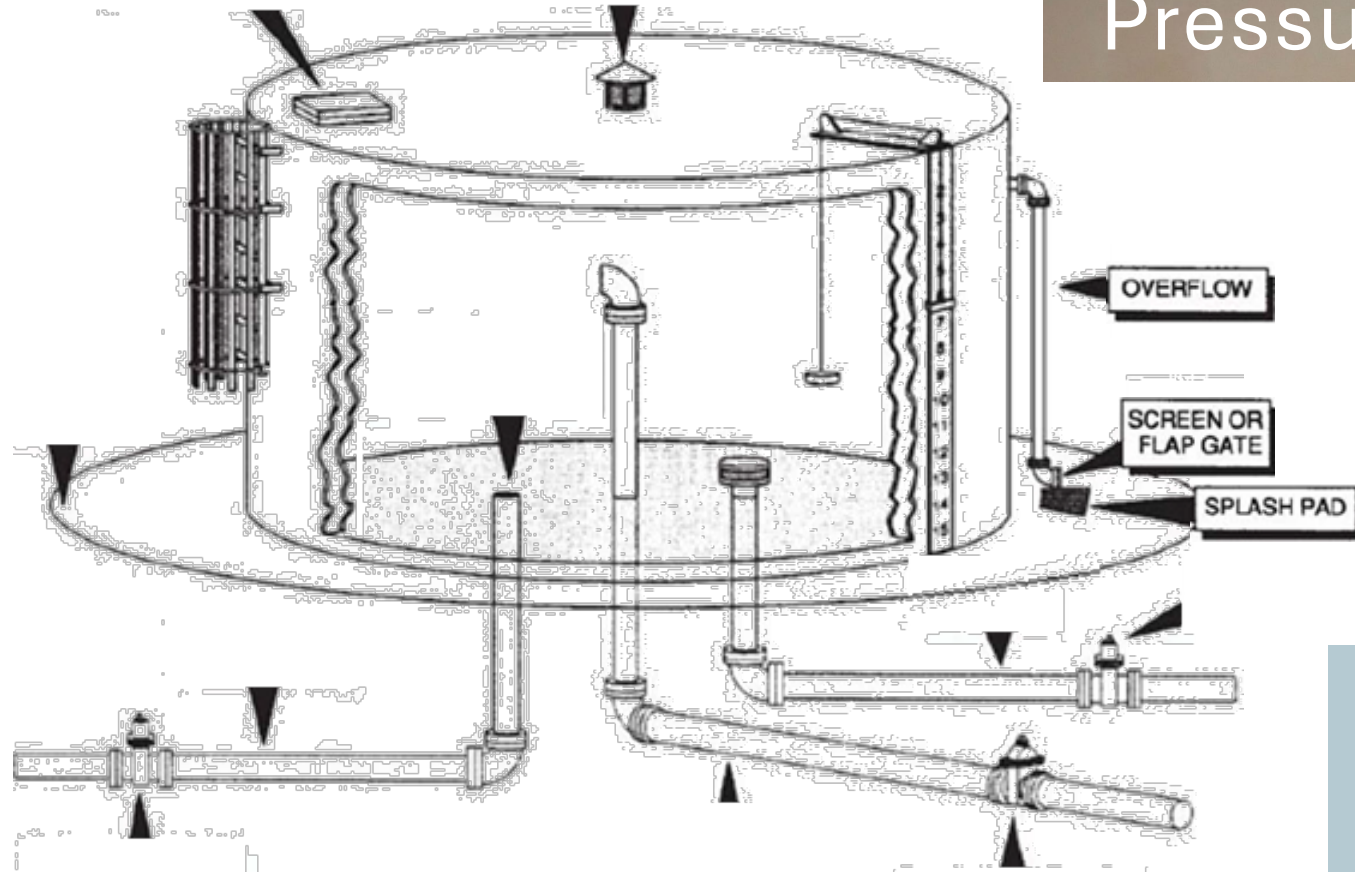


Tank Components

Foundation



Tank Components Overflow



Prevents Over
Pressurization

Protects
Water
Quality

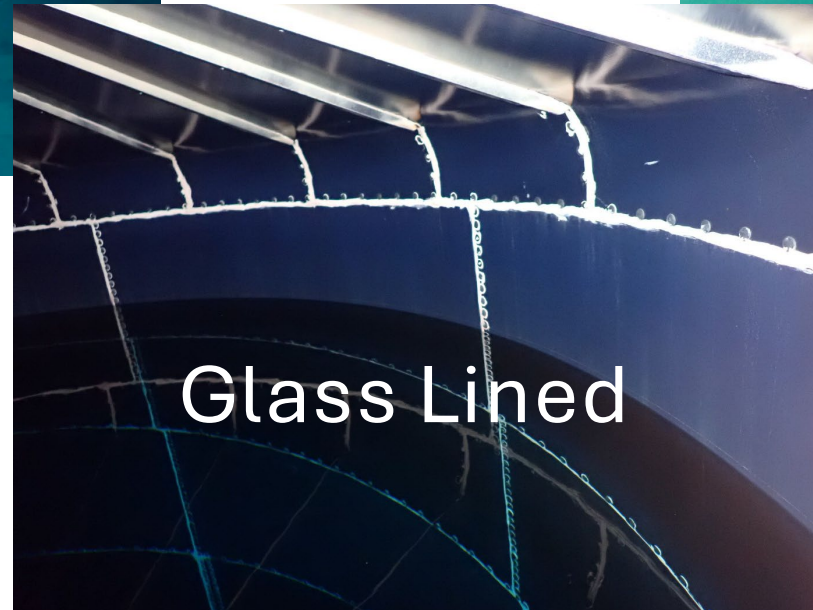
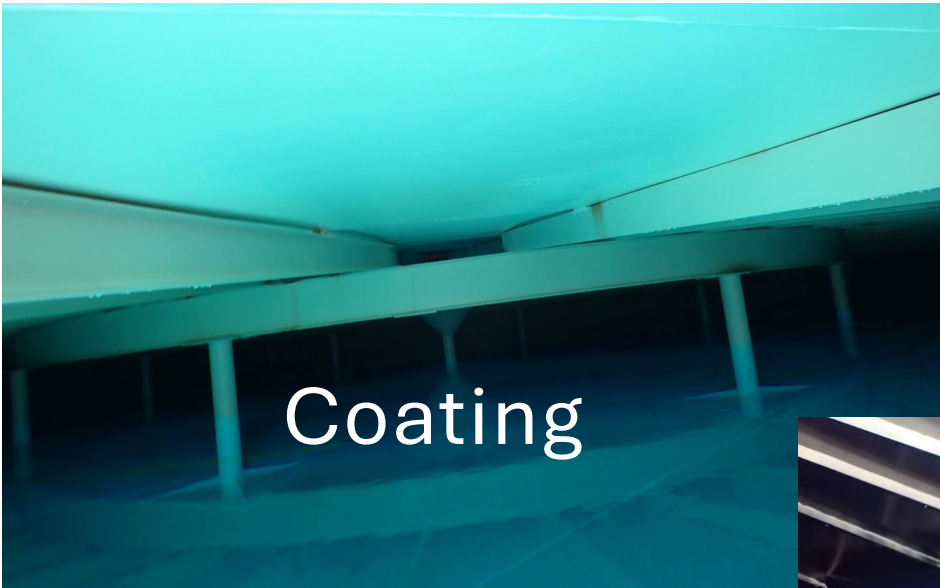
Prevents
Erosion

04/12/2024



Tank Components

Corrosion Protection



What
happens
if you
don't
maintain
your
tank?



What
happens
if you
don't
maintain
your
tank?



Storage tanks
should be
inspected and
cleaned every
3-5 years



Pumps

Classifying Pumps

Fluid Characteristics

- water type
- solids content
- chemical feed

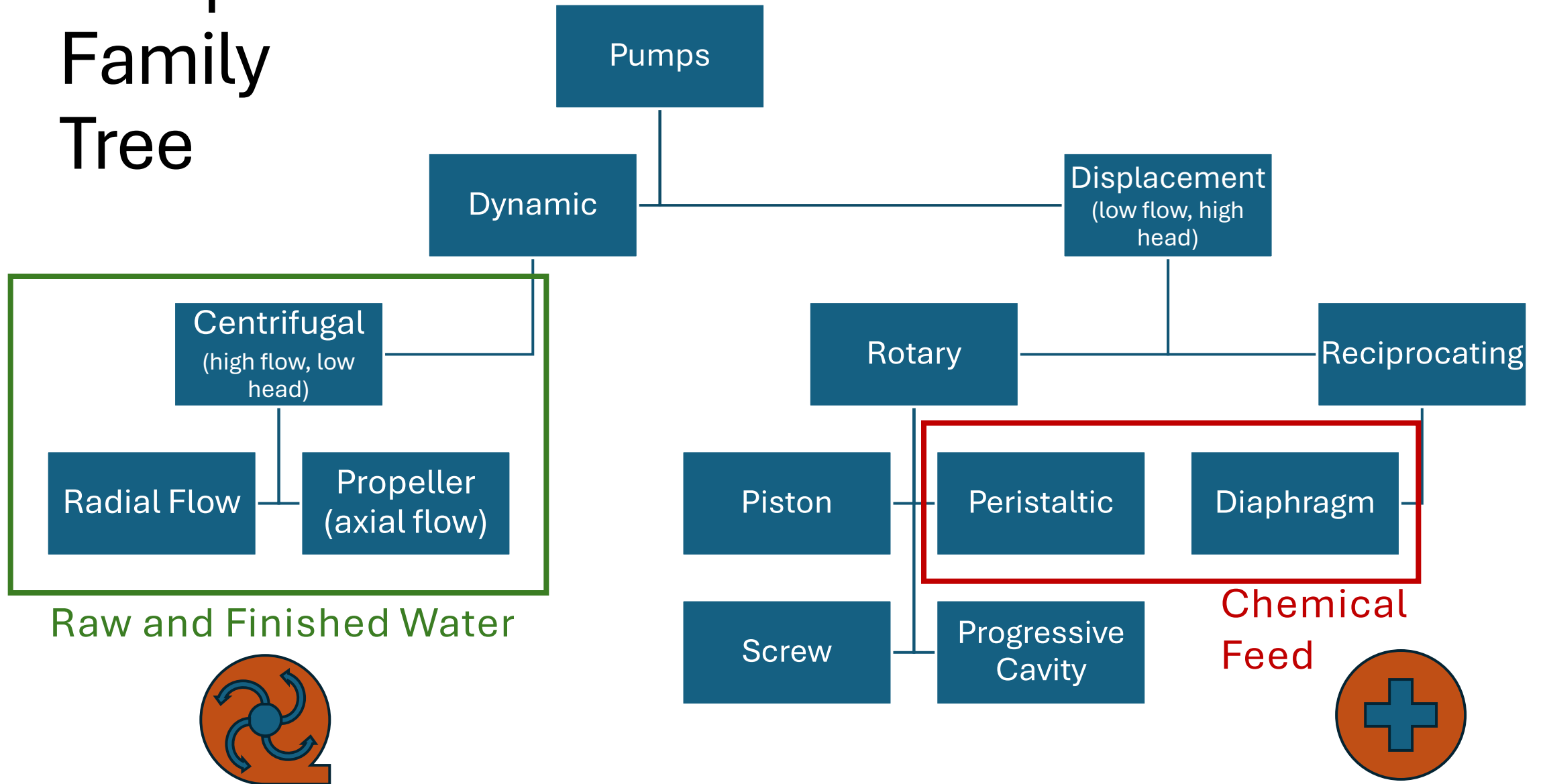
Pumping Conditions

- high head
- low head
- high flow
- low flow

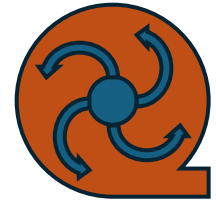
Principal of Operation

- centrifugal
- rotary
- reciprocating

Pump Family Tree



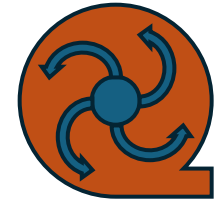
Centrifugal Principle



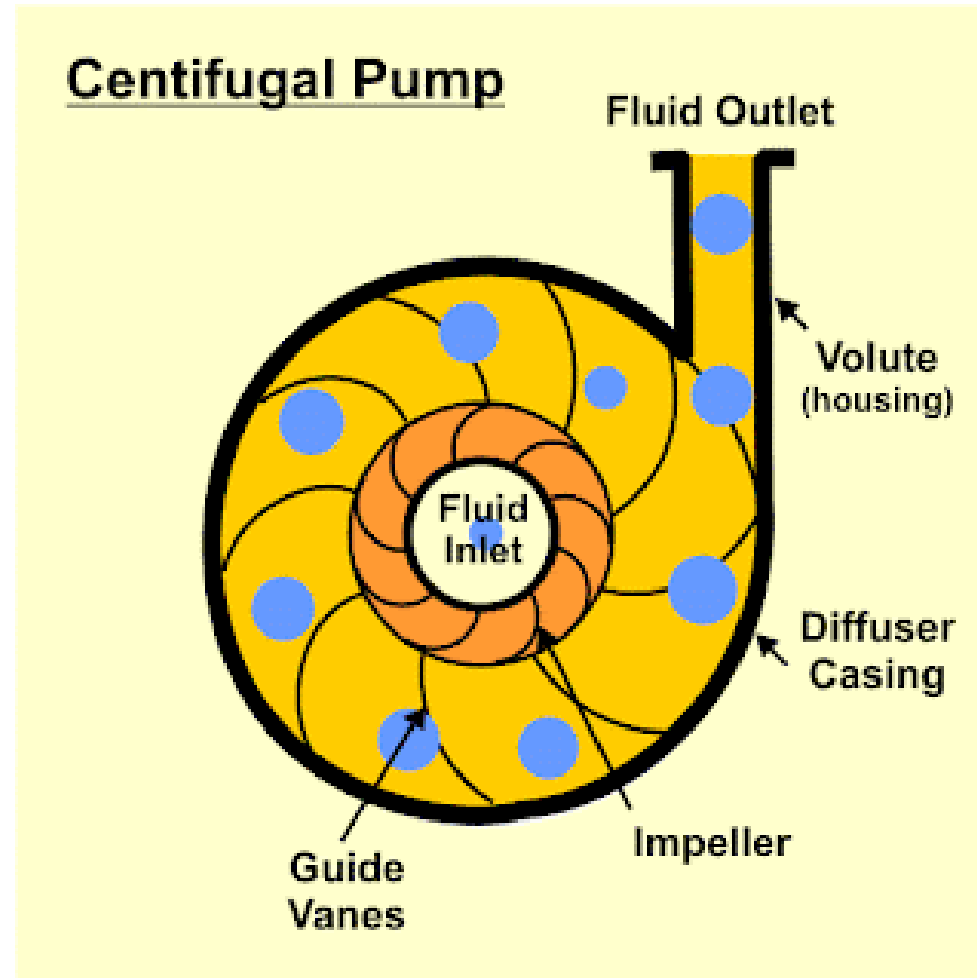
- All moving bodies tend to travel in a straight line. When forced to travel in a curve, they constantly try to travel in a tangent.



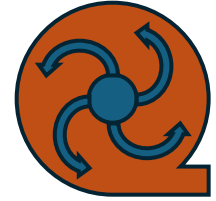
Centrifugal Pumps



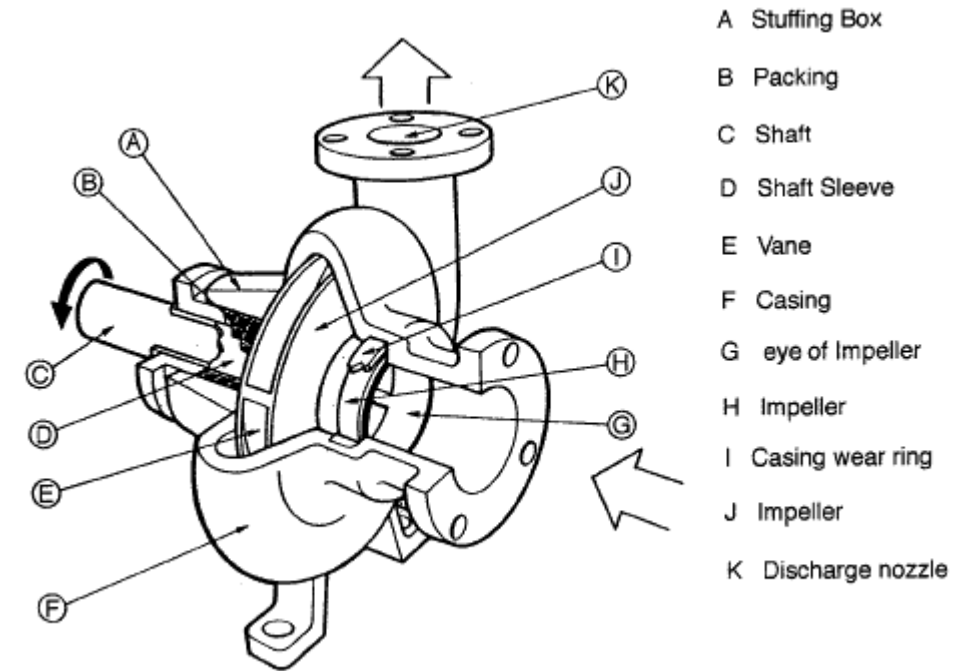
- Centrifugal force pushes water that's rotated in a circle away from the center of rotation.



Centrifugal Pump Parts

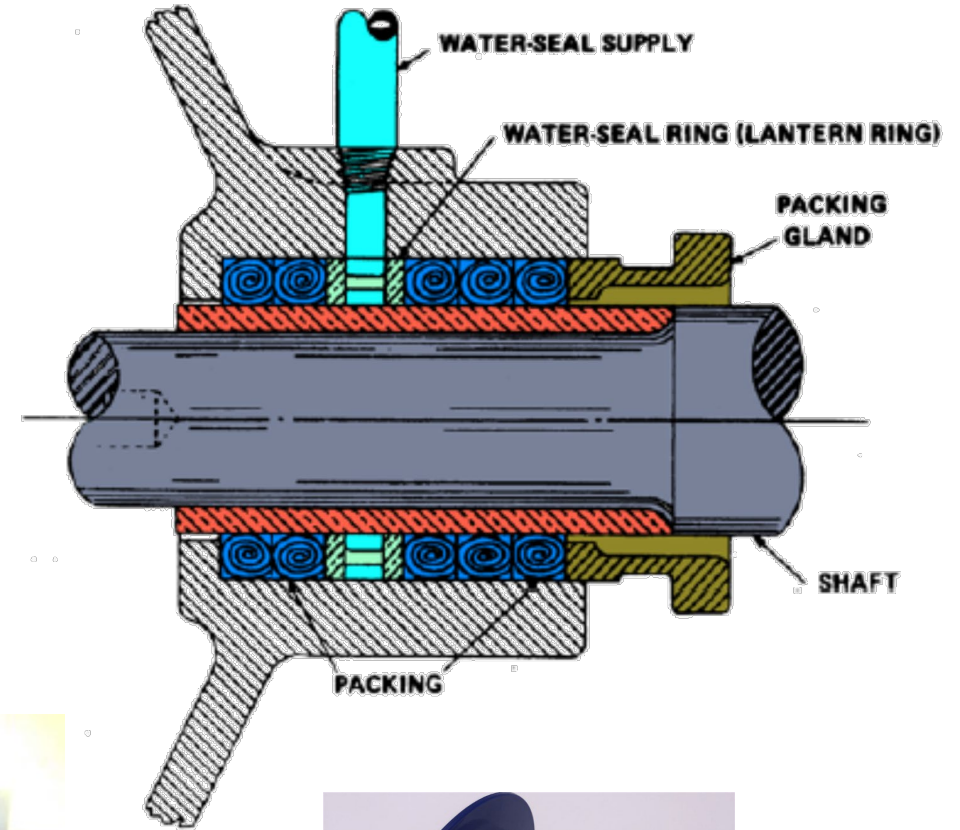
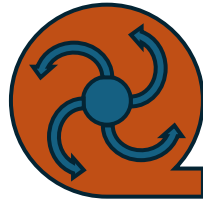


- Impeller
- Shaft (protect from corrosion and abrasion with sleeves)
- Bearings
- Coupling flange to connect pump to a separate motor
- Suction piping
- Volute (casing)
- Wear rings prevent internal liquid leakage
- Packing and stuffing boxes keep air from being sucked into the pump



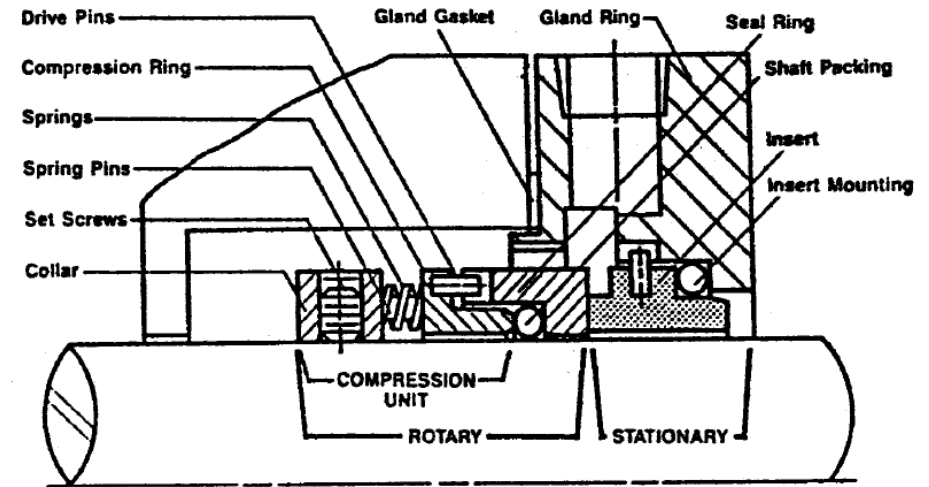
Shaft Seal with Stuffing Box

- Packing Gland
- Packing
- Lantern Ring
 - Protects by letting water and pressure in and keeping dirt out
 - Assists with cooling
 - Lubricates

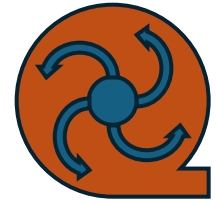


Shaft Seal with Mechanical Seal

- Two highly polished seal faces that create a watertight seal
 - One in gland ring that replaces packing gland
 - One attached to rotating shaft
- Seal surfaces don't touch when pump is running
 - Pressurized seal water forces seal apart
 - Friction loss and centrifugal force keeps seal from leaking

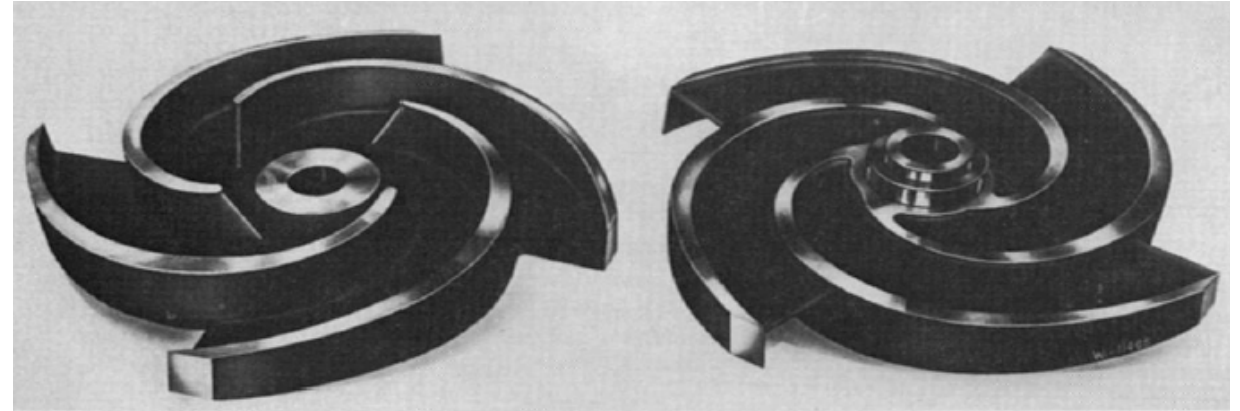


Impeller Types



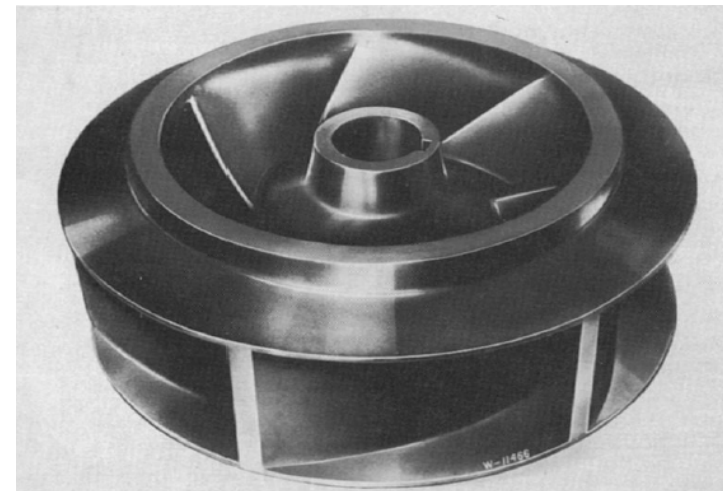
Open Radial

- Have larger flow paths
- Better for large solids
- Operate at lower heads and lower efficiencies



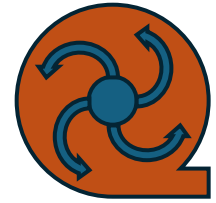
Closed Radial

- Vanes covered by shrouds on both sides
- Flow paths enclosed
- Can clog when pumping large solids

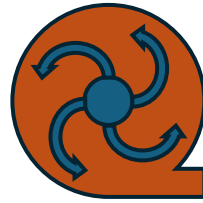


• Types of Centrifugal Pumps in Drinking Water

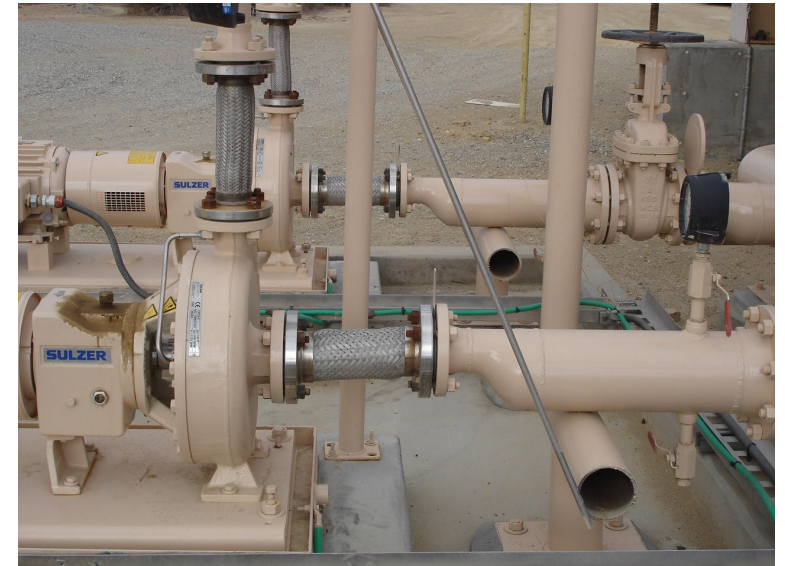
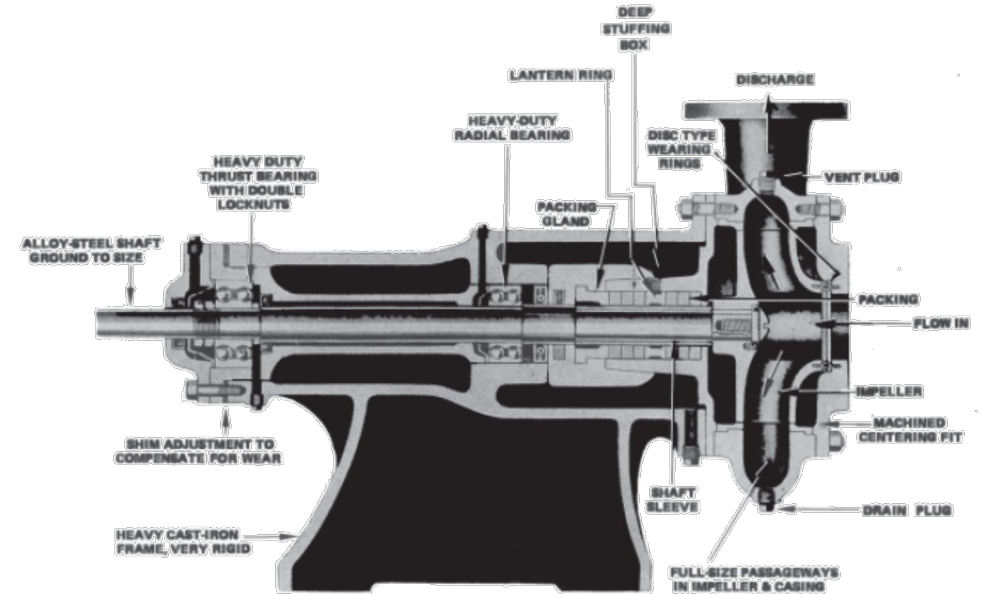
- End Suction
- Horizontal Split Case
- Vertical Mounted Horizontal Split Case
- Vertical Multistage
- Vertical Turbine



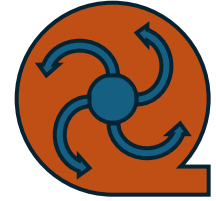
End Suction



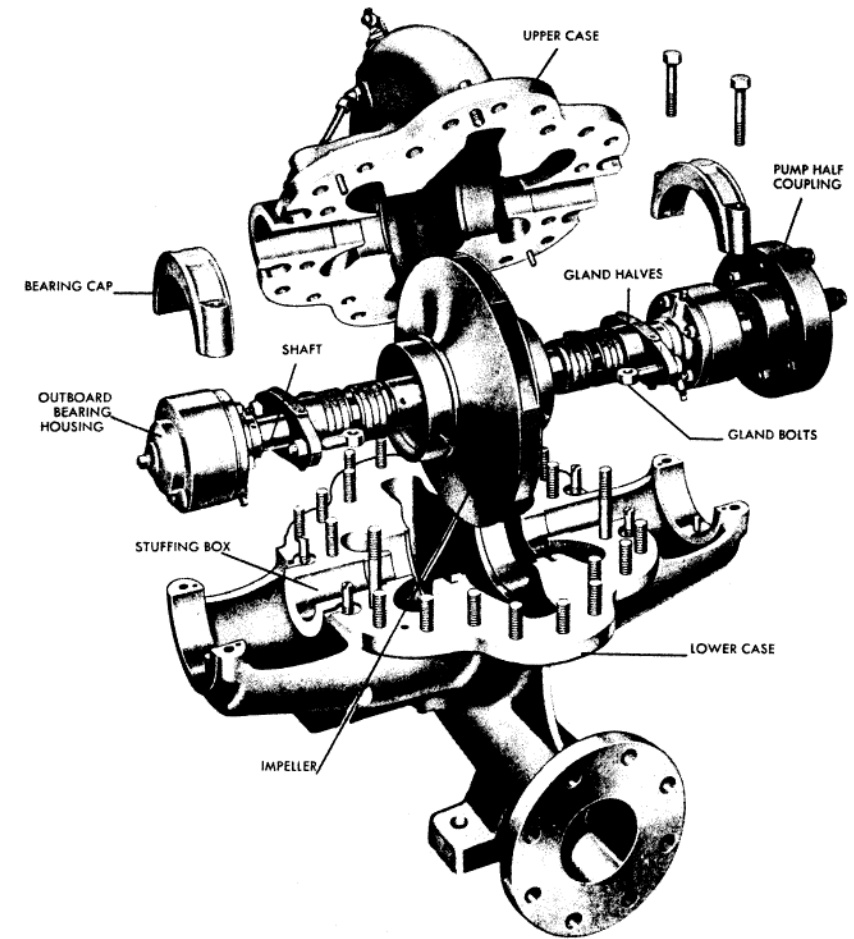
- Low flow, low head applications
- Vertical Discharge or rotate to where want discharge
- Can be close couple with motor or frame mounted with motor separate (shaft goes between motor and pump with coupling in between)
- More complex piping arrangement due to offset discharge (not straight through)



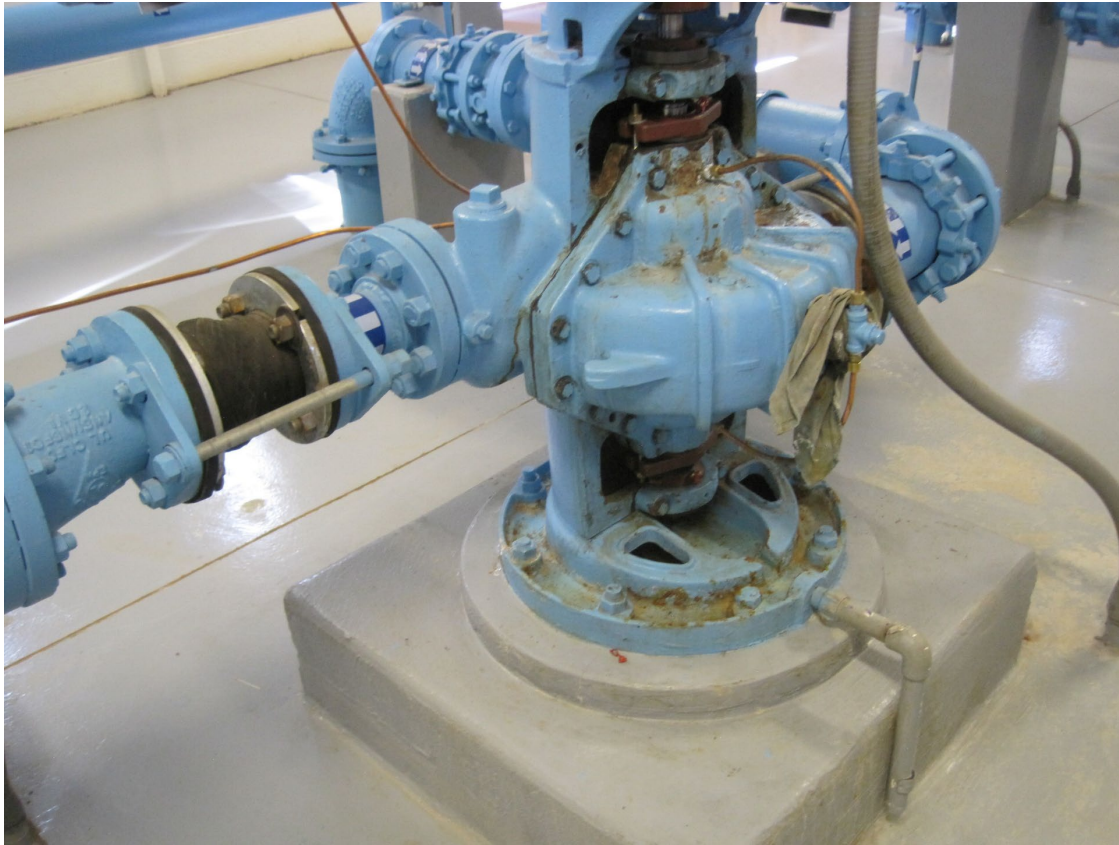
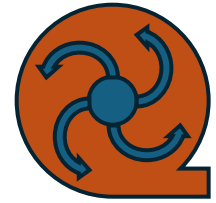
Horizontal Split Case



- High flow, low head applications
- Can be multistage with more than 1 impeller
- Split case open back design
- Straight through flow for easy piping installation
- Large footprints
- Horizontal design that can be vertically mounted to <footprint

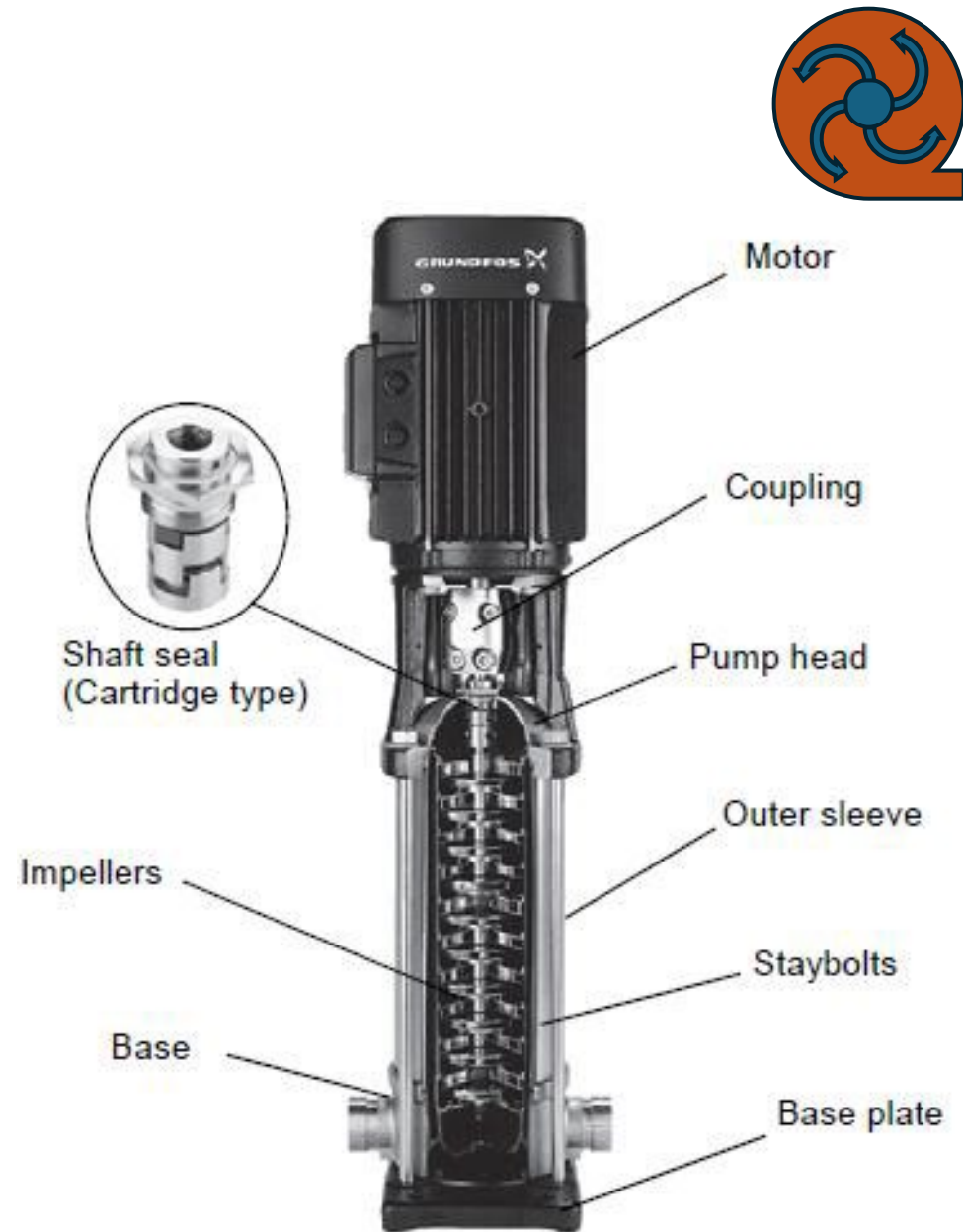


Vertical Mounted Horizontal Split Case



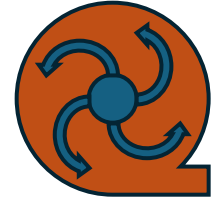
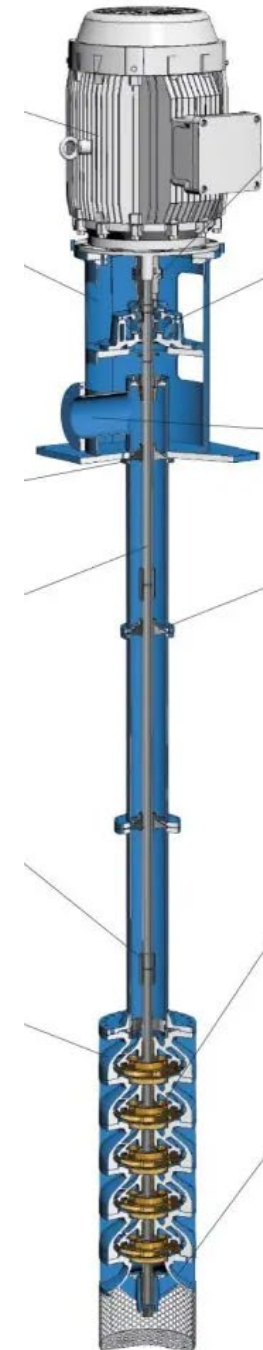
Vertical Multi-Stage

- Clean water applications with low flows and high head
- Multiple impellers
- Small footprint
- Straight through flow for easy piping installation
- Durable and long lasting



Vertical Turbine

- Pump bowls (casing, impeller, shaft) submerged in water at the end the column pipe
- Motor is mounted on top
- Multiple impellers staged at the end of a vertical shaft can create high flows at high pressures
- Water flows into the bottom and out of the top
- See in booster pump stations with a wet well or ground water wells for drinking water



Pump Appurtenances

- Automatic Control System



Pump Appurtenances

- Elapsed Time Meter



Pump Appurtenances

- Pump Redundancy (more than one pump)



Pump Appurtenances

- Flow Meter



Pump Appurtenances

- Check Valve
After
Discharge



Pump Appurtenances

- Pressure Gauge on Suction Side and Discharge Side

Suction Side



Discharge Side

Pump Appurtenances

- Isolation Valves



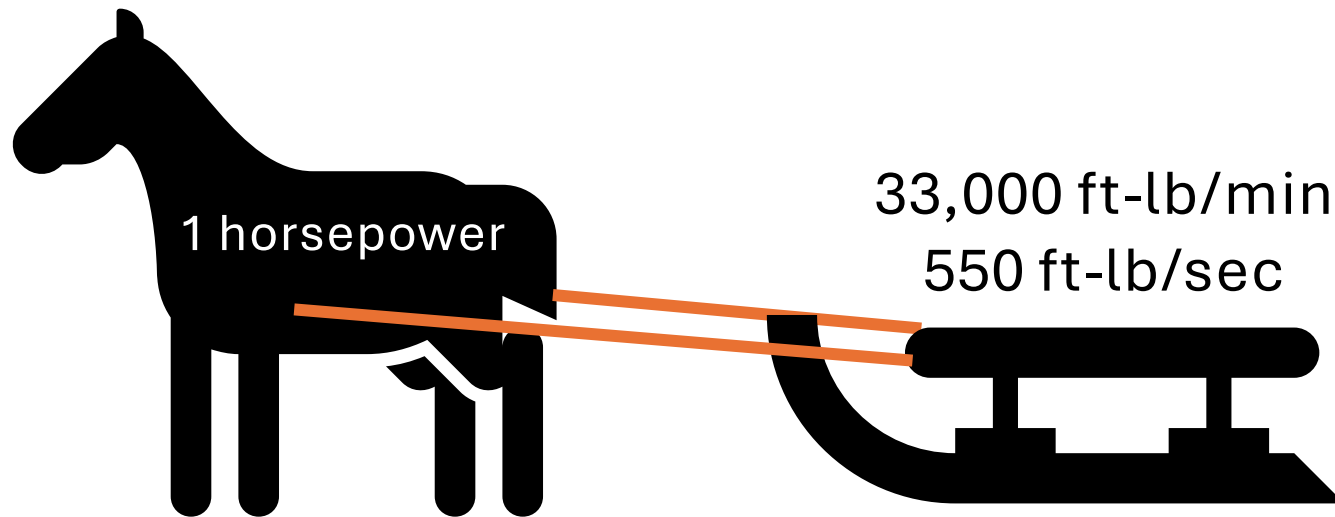
Pump Performance

- Flow (gpm)
- Head (ft)
- Pressure (psi)
- Horsepower (hp)



Pump Performance - Horsepower

- Work – what a pump does by pushing a certain amount of water at a given pressure (foot-pound, ft/lb)
- Power – the rate at which work is done (ft-lb/sec)



Pump Performance - Horsepower

- Hydraulic (water) horsepower (whp) – the amount of power supplied to a pump that is actually used to move water

$$\text{Horsepower, Water, hp} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{3,960}$$

- Brake horsepower (bhp) – depends on pump efficiency (not all power supplied to the pump will be used to lift water)

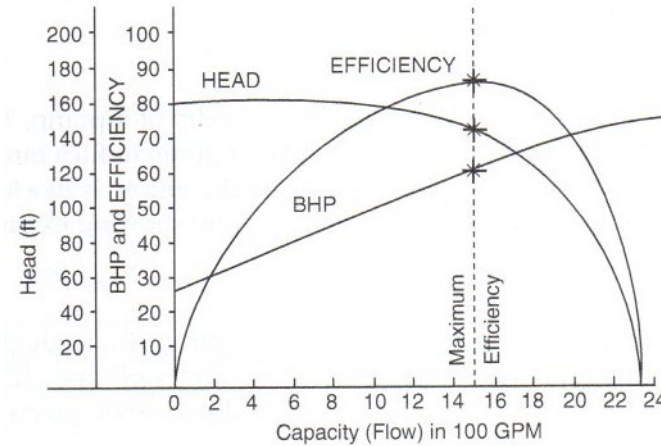
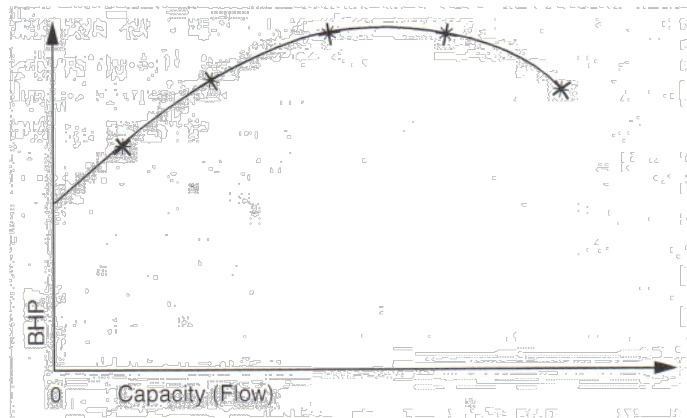
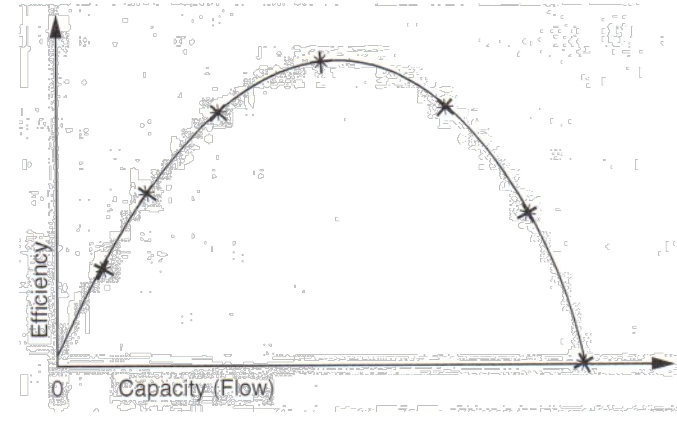
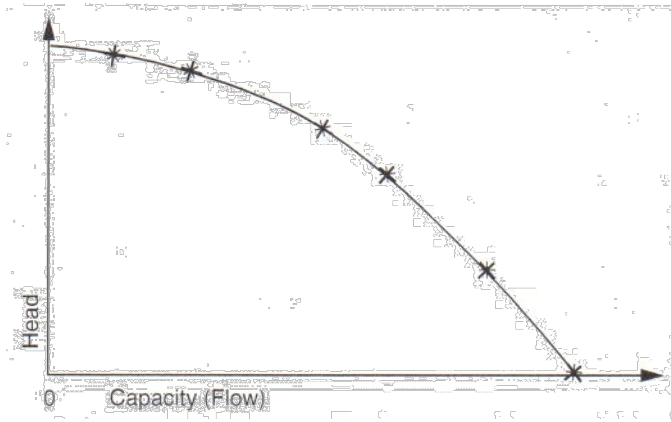
$$\text{Horsepower, Brake, hp} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{(3,960)(\text{Pump Efficiency, \% expressed as a decimal})}$$

- Motor horsepower (mhp) – is equivalent to the electric power supplied to the motor

$$\text{Horsepower, Motor, hp} = \frac{(\text{Flow, gpm})(\text{Head, ft})}{(3,960)(\text{Pump Efficiency, \% expressed as a decimal})(\text{Motor Efficiency, \% expressed as a decimal})}$$

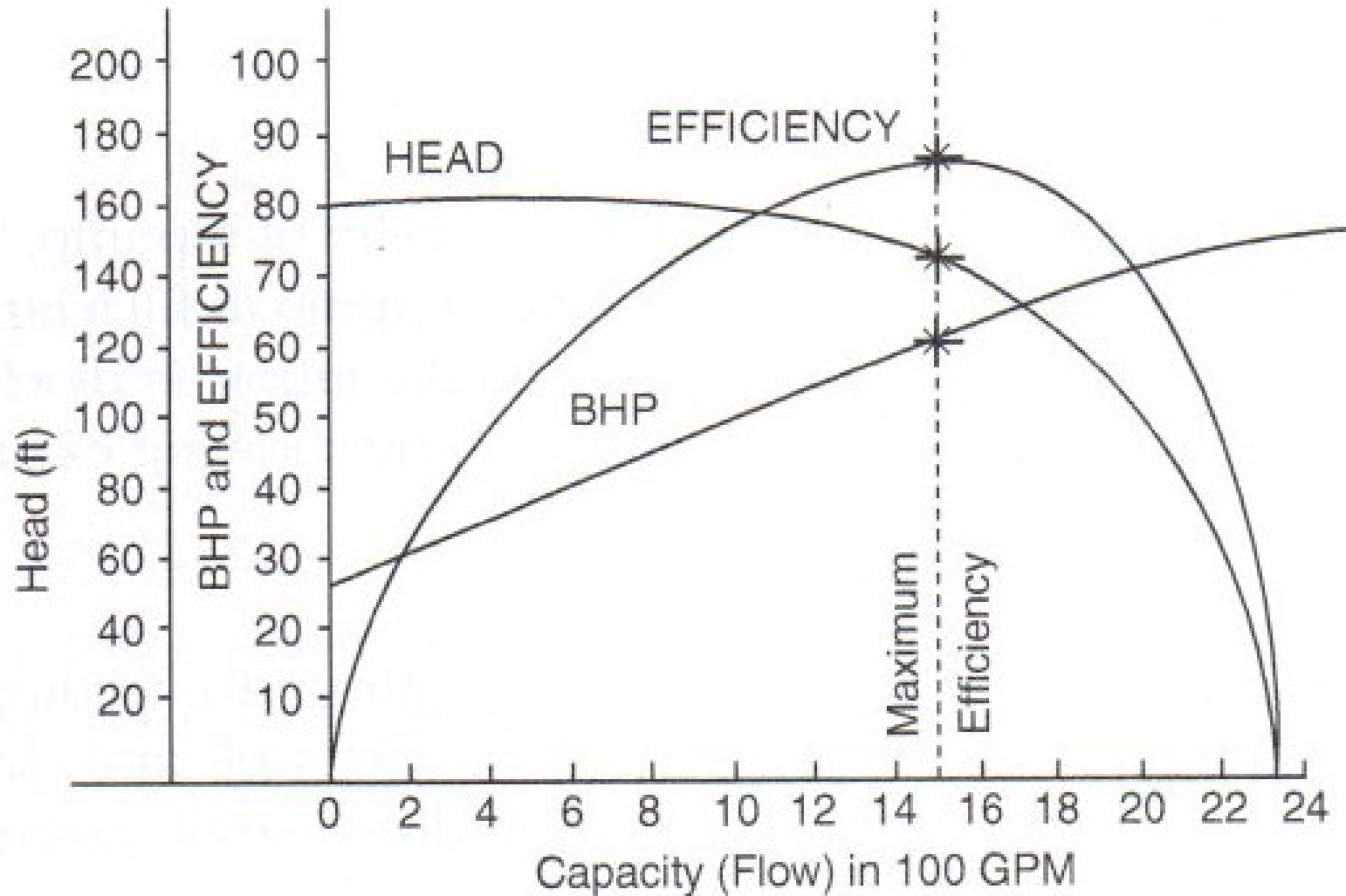
Evaluating Pump Performance

Pump Curves



Evaluating Pump Performance

Pump Curves



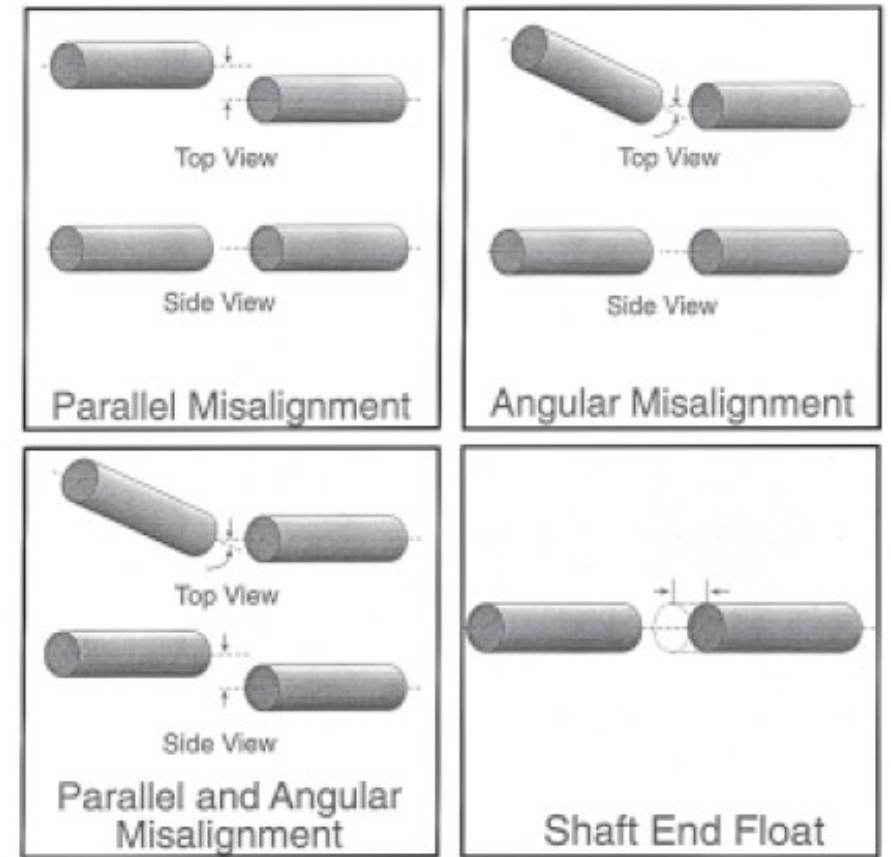
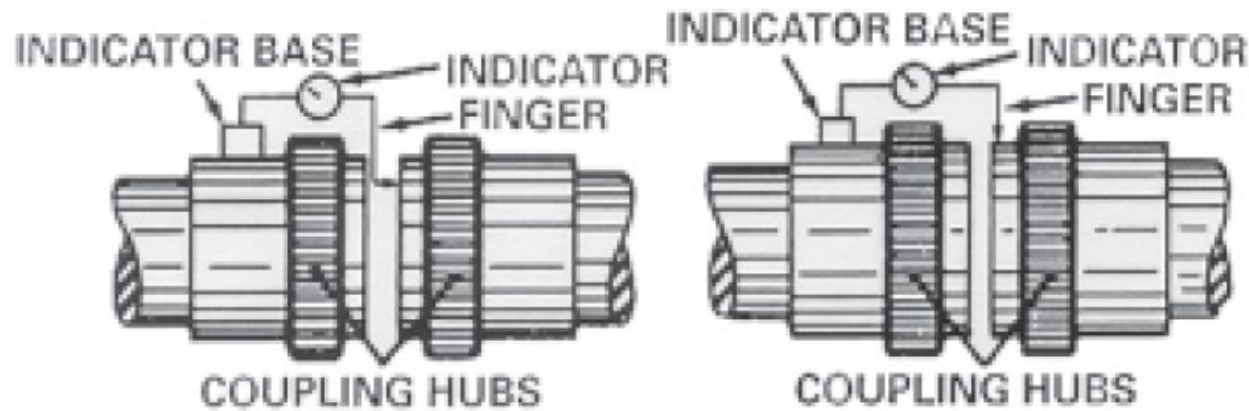
Pump Tips

- Use a screen on suction piping if there is any danger of foreign matter being sucked into the pump
- Never pump a liquid for which the pump was not designed
- Always keep the right amount of lubricant in bearings



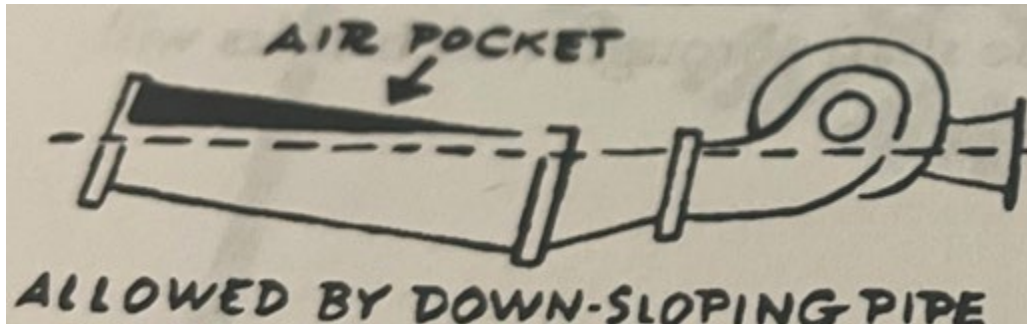
Pump Tips

- Keep pump and motor flanges parallel vertically and angularly (axially) at all times. Flexible couplings won't fix if excessive.
 - Checking alignment should be part of regular pump maintenance



Pump Tips

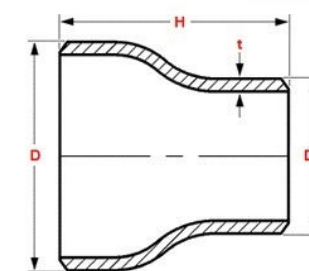
- Down sloping suction piping should be corrected to prevent loss of suction



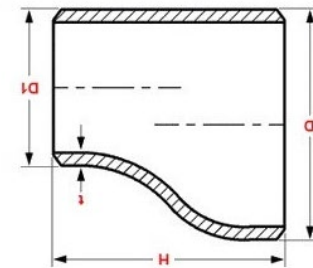
- Reducers at pump should be eccentric,
not concentric



Concentric Reducer

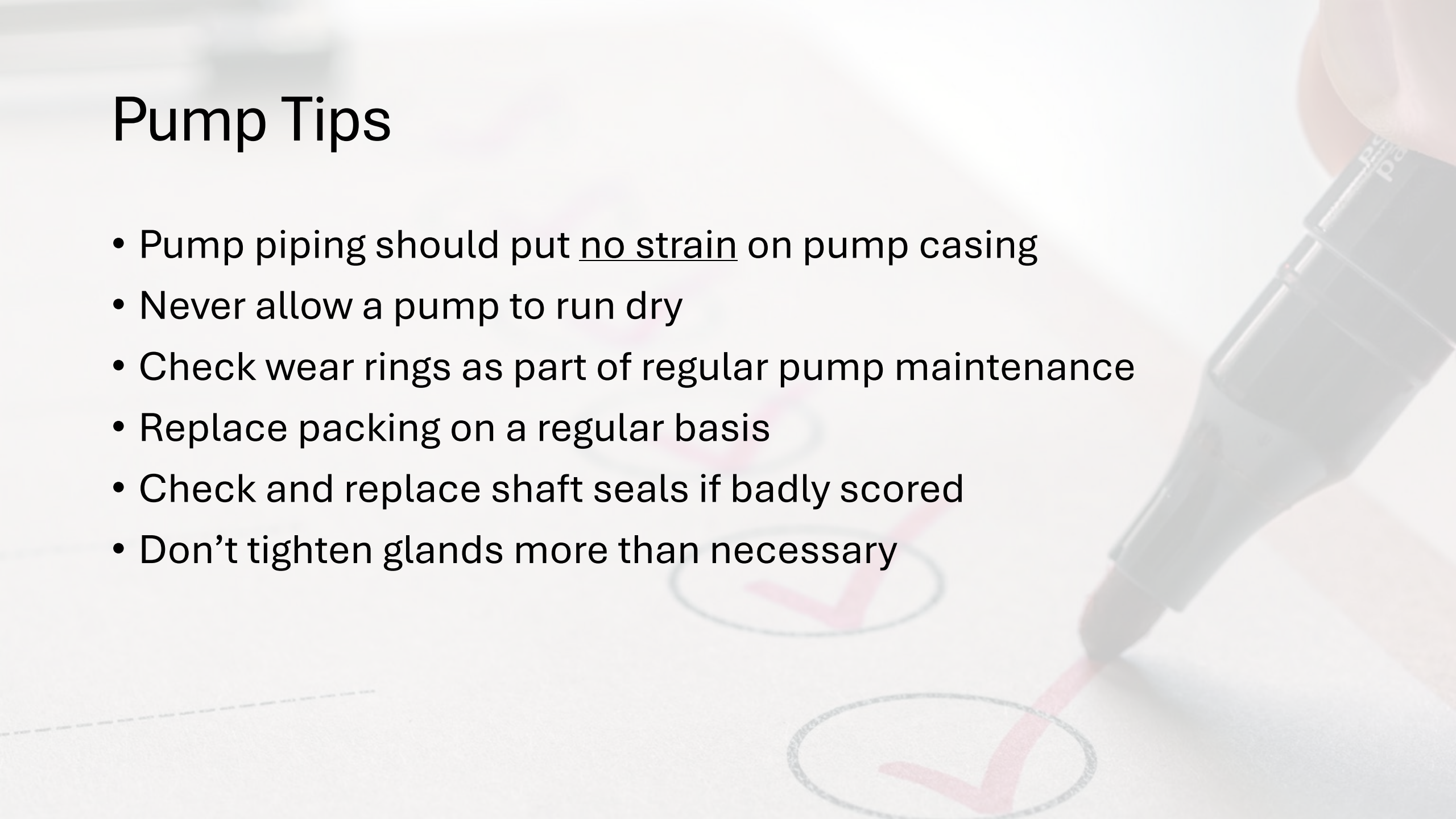


Eccentric Reducer



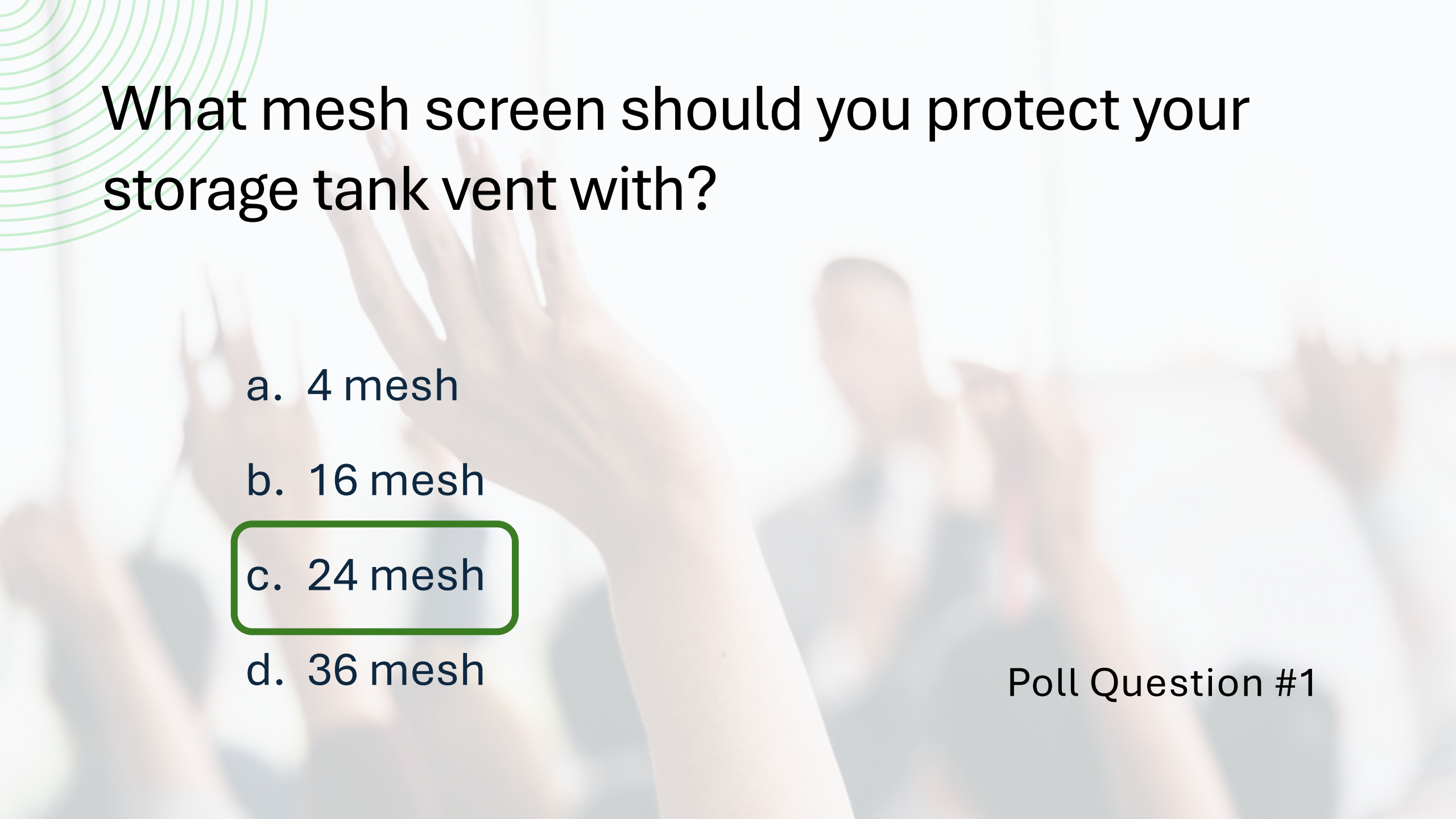
Pump Tips

- Pump piping should put no strain on pump casing
- Never allow a pump to run dry
- Check wear rings as part of regular pump maintenance
- Replace packing on a regular basis
- Check and replace shaft seals if badly scored
- Don't tighten glands more than necessary



Common Pump Problems

- Cavitation – sounds like you are pumping rocks, happens when pump tries to discharge water faster than what can be drawn into the pump creating pockets of water vapor that collapse
 - Loss of discharge pressure
 - Closed suction valve
 - Low suction head
 - Suction line obstruction
- Air Locking – air or other gasses become trapped in pump volute, become compressed and lead to pump shutoff
- Loss of Prime – water drains out of pump volute and impeller cannot create suction



What mesh screen should you protect your storage tank vent with?

- a. 4 mesh
- b. 16 mesh
- ☒ c. 24 mesh
- d. 36 mesh

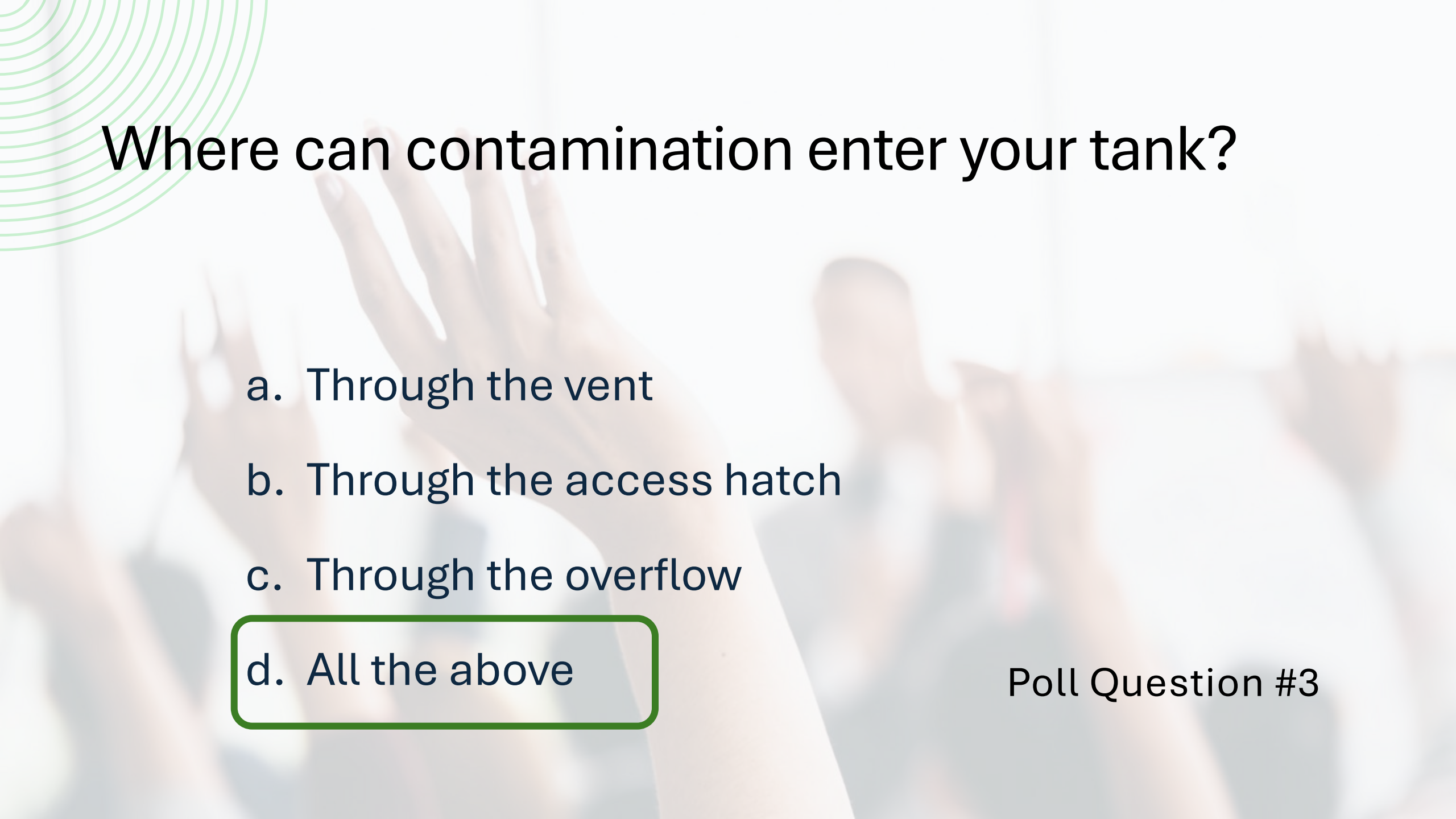
Poll Question #1



How often should your tank be inspected and cleaned?

- a. Every year
- b. Every 1-3 years
- c. Every 3-5 years
- d. Every 10 years

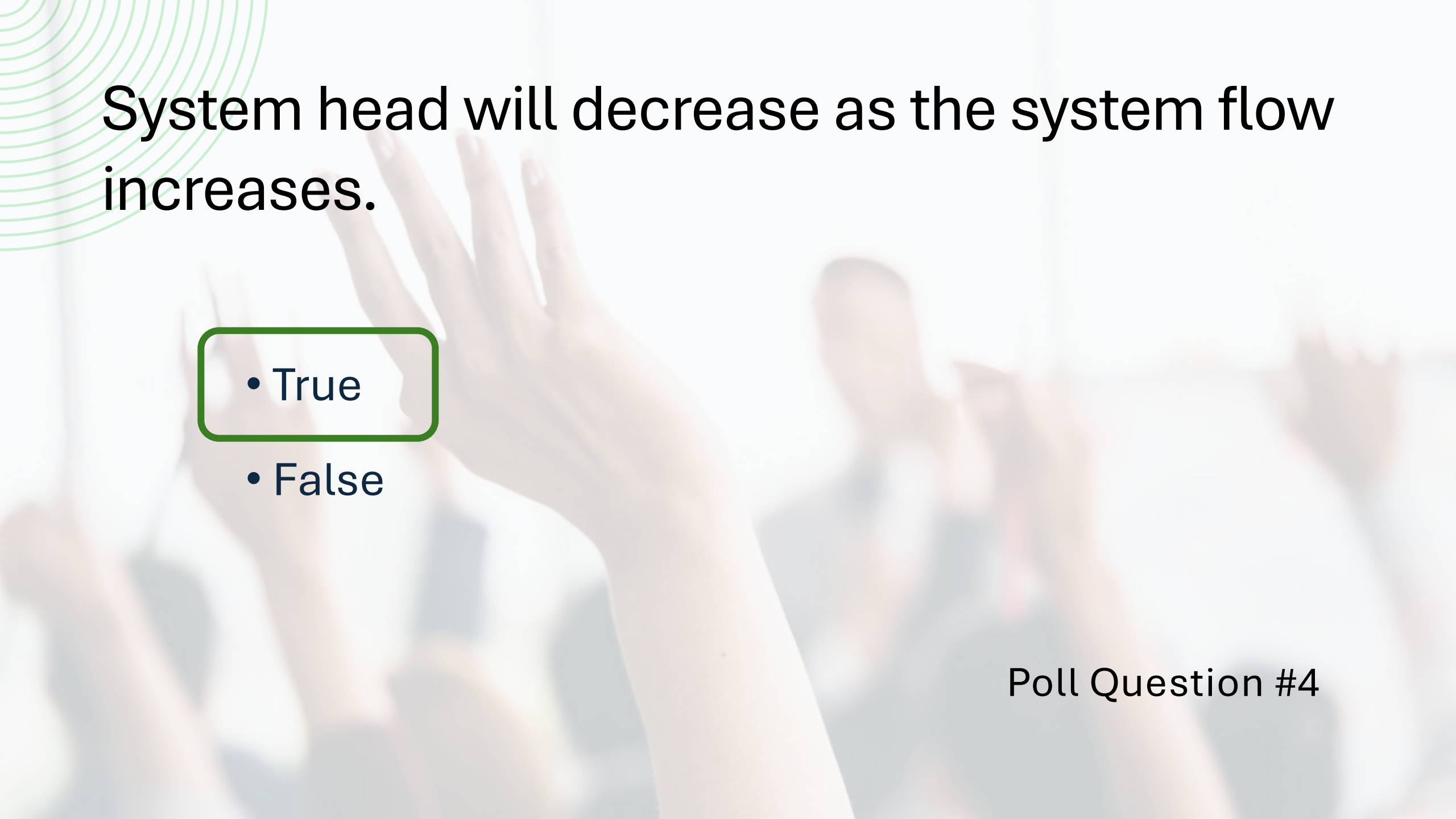
Poll Question #2



Where can contamination enter your tank?

- a. Through the vent
- b. Through the access hatch
- c. Through the overflow
- d. All the above

Poll Question #3

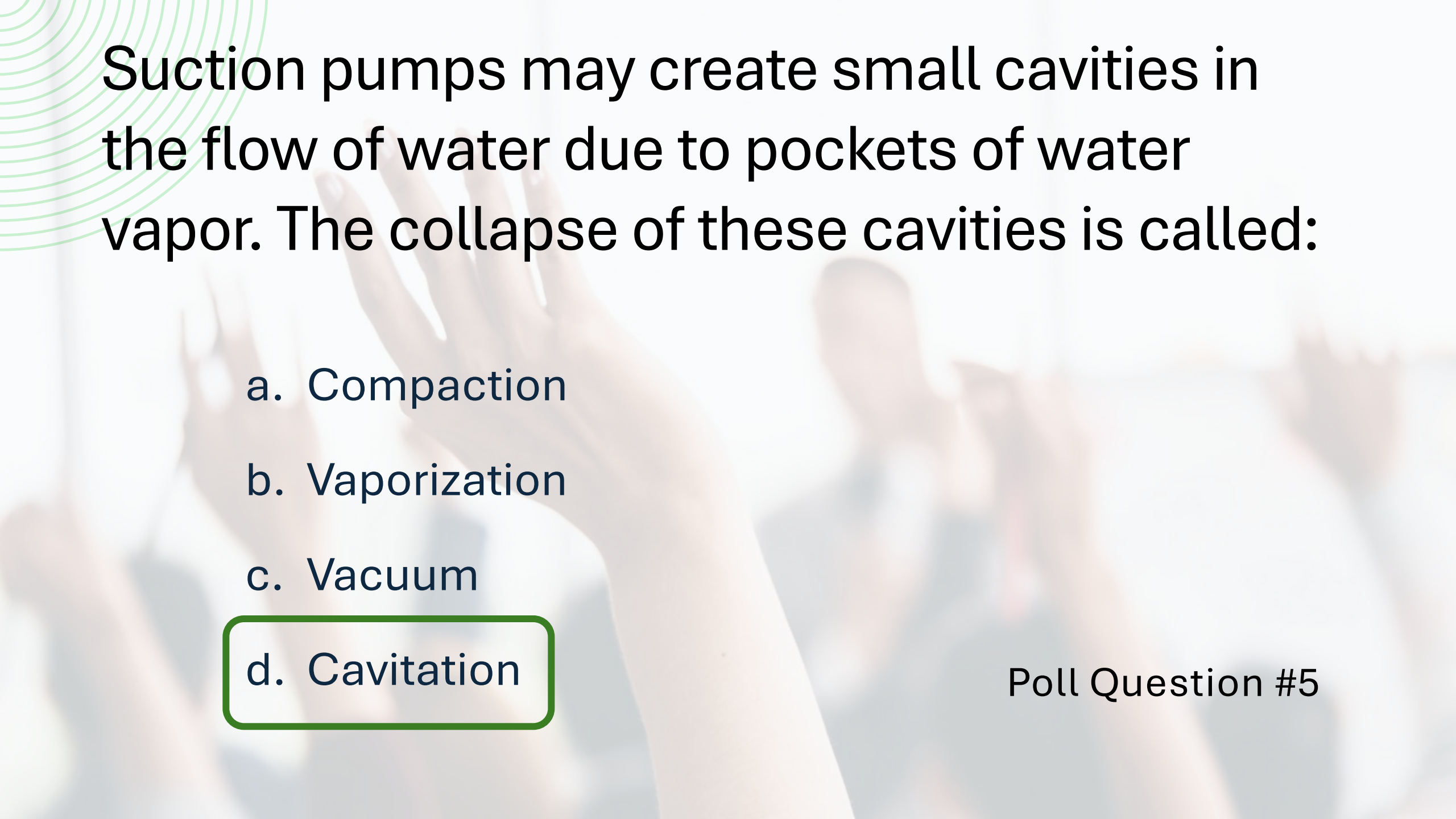


System head will decrease as the system flow increases.

• True

• False

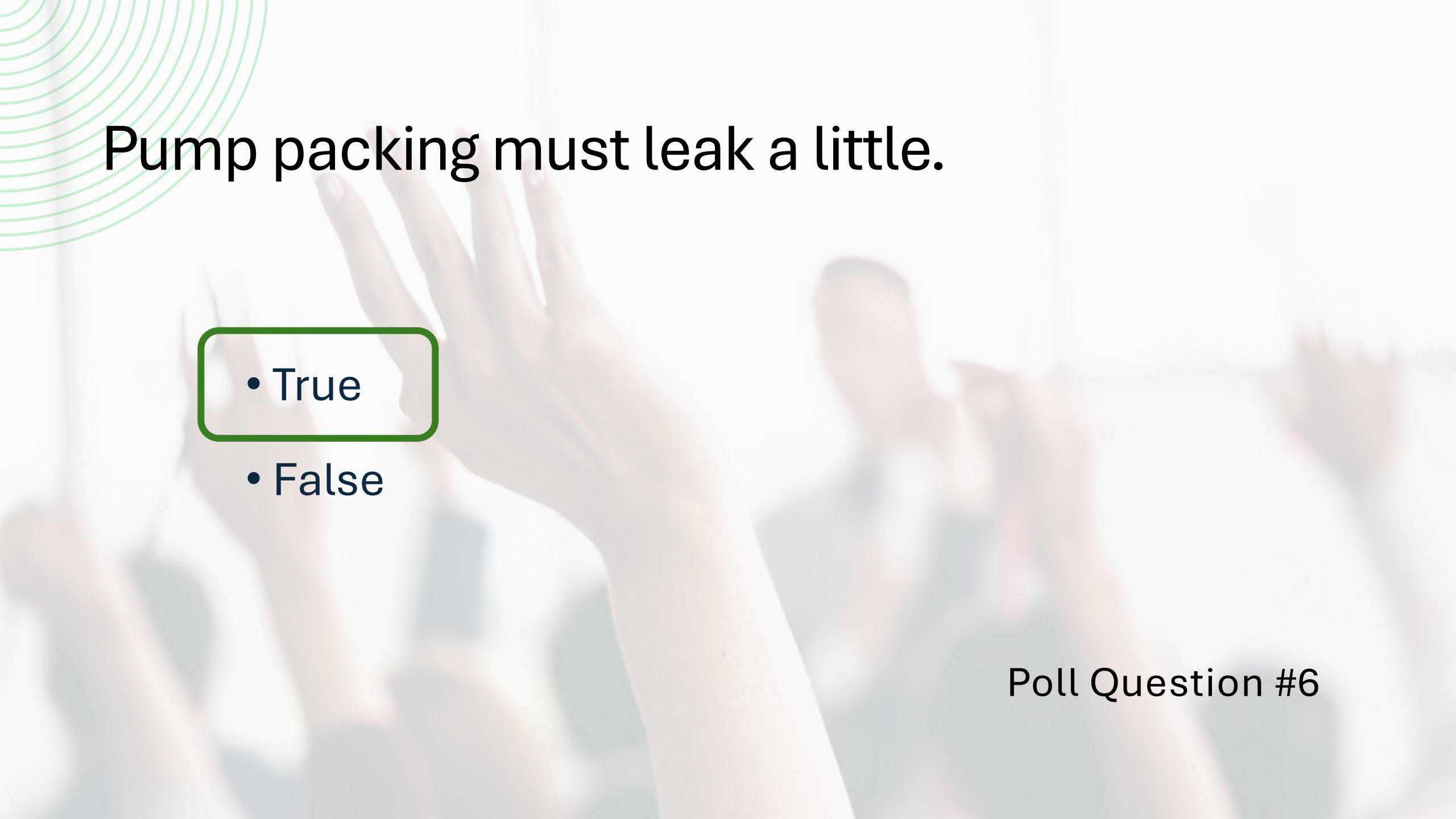
Poll Question #4



Suction pumps may create small cavities in the flow of water due to pockets of water vapor. The collapse of these cavities is called:

- a. Compaction
- b. Vaporization
- c. Vacuum
- d. Cavitation

Poll Question #5



Pump packing must leak a little.

- True

- False

Poll Question #6

Next time:

Date	Topic
1/22/26	Alternative Treatment Processes (e.g. fluoridation, ion exchange, RO...)
2/5/26	Drinking Water Treatment Math & Concept Review
2/19/26	Safety Program Basics (including personal safety, equipment safety, facility safety)
3/5/26	Lead & Copper Rule, Corrosion Control
3/19/26	Distribution Systems 1: Hydraulics, Pipe Types, Selection, Installation, and Water Quality
4/2/26	Distribution Systems 2: Valves, Hydrants, Meters, and Service Connections
9/17/26	Distribution Systems 3: Storage and Booster Pumping
10/1/26	O&M: Pumps, Main, and Appurtenance Maintenance (including pressure monitoring, valve exercising, and flushing)
10/15/26	O&M: Cross Connection Control
10/29/26	O&M: Distribution System Math and Concept Review
11/12/26	Sampling & Lab Procedures/Analysis/Interpretation
12/3/26	Management Overview (including organization, communication, PR & record keeping)
12/17/26	Drinking Water Practice Exam and Review

Links to recordings and material are available on our website at <https://swefc.unm.edu/home/op-cert-trainings/>

CONTACT INFORMATION



SOUTHWEST ENVIRONMENTAL FINANCE CENTER

SW EFC email:
swefc@unm.edu

Department of Civil Engineering MSCo1 1070
1 University of New Mexico
Albuquerque, NM 87131
505-277-0644
swefc@unm.edu
<http://swefc.unm.edu>